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(54) METHOD AND APPARATUS FOR REMOVING COATINGS AND OXIDES FROM SUBSTRATES

(75) Inventors: **Edward D. Neese**, Sewickley; **Peter S. Kullen**, Penn Hills, both of PA (US); **Eugene Valentine**, Massilon, OH (US)

(73) Assignee: **International Processing Systems, Inc.**, Sewickley, PA (US)

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(51) **Int. Cl.**[7] **B24B 1/00**; B24C 1/00
(52) **U.S. Cl.** **451/38**; 451/39; 451/91
(58) **Field of Search** 451/28, 36, 38, 451/39, 91, 75, 99, 102; 239/590; 29/81.08, 81.07; 134/2, 15, 41, 34, 18, 28, 32

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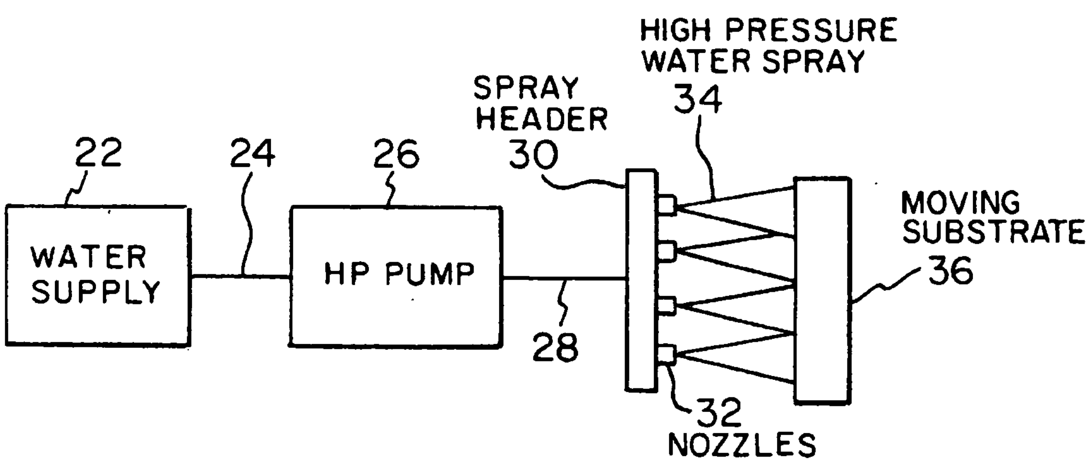
Primary Examiner—Derris H. Banks
(74) *Attorney, Agent, or Firm*—Webb Ziesenheim Logsdon Orkin & Hanson, P.C.

(57) **ABSTRACT**

A method and apparatus for removing coatings and oxides from substrates that includes a conveyor for moving a substrate in a first direction, at least one nozzle positioned away from the conveyor in position to direct the stream of fluid toward the conveyor and a high pressure fluid supply in fluid commination with the nozzle wherein the pressurized fluid supply is arranged to supply a pressurized fluid to exit the nozzle and direct the fluid at a high velocity to a surface of the substrate for removing a liquid or solid film from the substrate. The method includes providing a pressurized fluid to a stationary nozzle, directing the pressurized fluid from the nozzle in a high velocity fluid stream toward a moving object having a coating and contacting the fluid stream with the object whereby a force of the fluid removes the coating.

29 Claims, 2 Drawing Sheets



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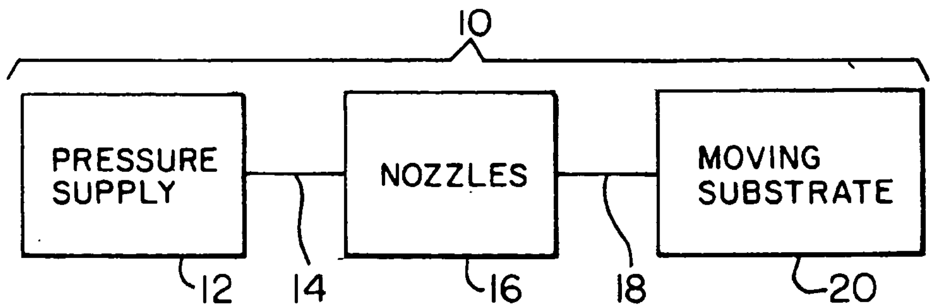

FIG. 1

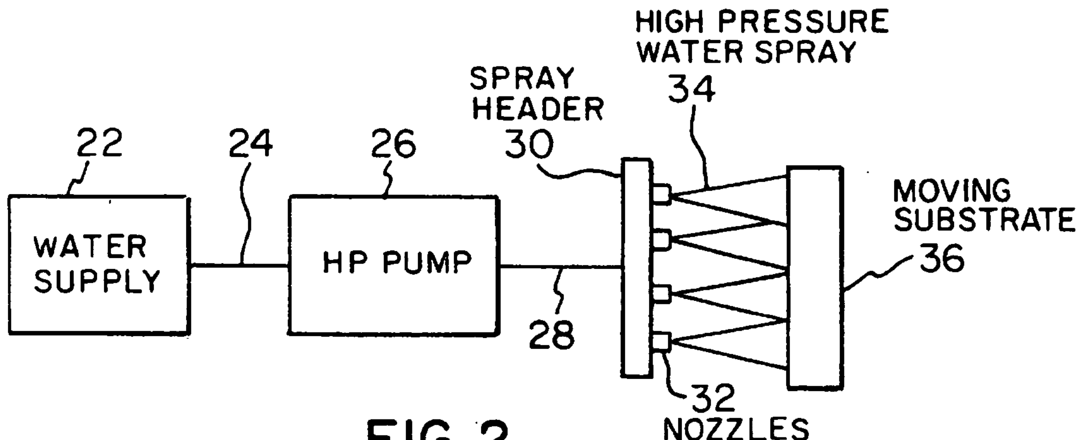

FIG. 2

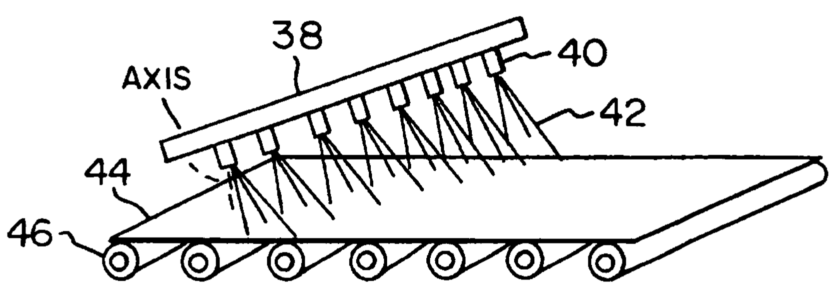

FIG. 3

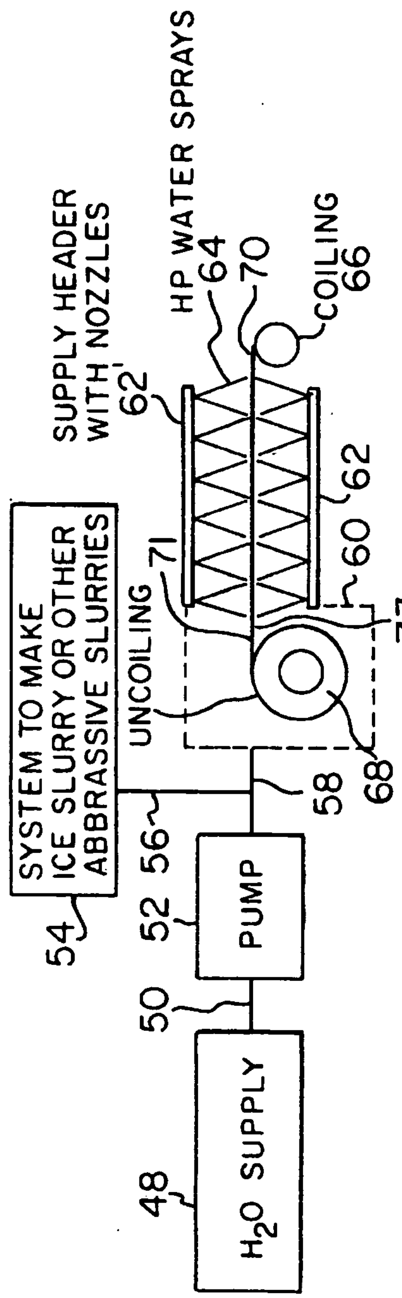

FIG. 4

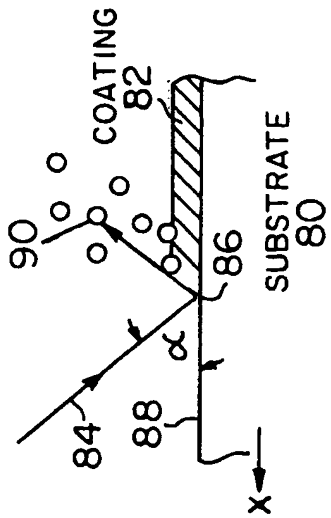

FIG. 5

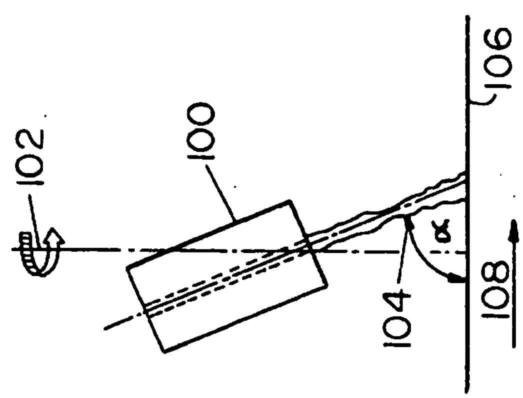

FIG. 6

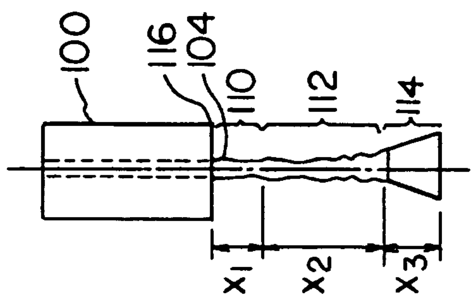

FIG. 7

METHOD AND APPARATUS FOR REMOVING COATINGS AND OXIDES FROM SUBSTRATES

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 60/111,204, filed Dec. 7, 1998 entitled "METHOD AND APPARATUS FOR REMOVING COATINGS FROM SUBSTRATES".

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to cleaning of materials or parts using pressurized water where the nozzle or banks of nozzles are fixed with respect to a moving target or product.

2. Description of the Prior Art

Surface cleanliness, a key parameter in materials processing and manufacturing, significantly affects the quality of a product. Cleaning in the manufacturing environment has traditionally been carried out by many methods, but these generally break down into two categories: chemical and mechanical. Chemical methods have been popular in many industries, especially heavy industries, such as primary metals production, because of the thoroughness of the cleaning, high quality, high productivity and the low cost. Typical chemicals used in such cleaning processes are: water, acids, soaps, chlorofluorocarbon (CFC's), chlorinated hydrocarbons, aromatic hydrocarbons, and aliphatic hydrocarbons. Mechanical processes are typically used where the required surface quality is lower, or chemical processes are less convenient or less effective. Typical mechanical cleaning methods are: grit blasting, shot blasting, grinding, brushing and milling. The use of pressurized water for cleaning is a hybrid of the chemical process and the mechanical process. Specifically, water is in-itself a solvent and when sprayed at high pressures, it acts as an abrasive.

The chemical cleaning methods, while still quite popular, have been waning due to environmental and health concerns. The Clean Air Act Amendments of 1990, as well as other environmental legislation, have reduced the usage of some of the most effective chemicals, such as the volatile organic compounds (VOC's) and phosphate based detergents. The effect has been to send industry looking for the best alternative technologies. Currently used chemical cleaning methods, such as acid pickling of steel, tend to generate a vast quantity of waste that must be disposed of or recycled. And so, the advantages of superior quality and high productivity for chemical methods may soon be lost due to the overwhelming costs of environmental control and waste disposal.

Pressurized water has been used in hot metal production lines. Specifically, during reheating of steel slabs and ingots for hot rolling, the metal reacts with the oxygen in the air to form a thick oxide scale. The scale, formed prior to hot rolling, is referred to as "primary scale". This flaky, porous scale is relatively thick and friable. Typically, it is 0.040–0.050 inches thick. Primary scale is removed prior to hot rolling by a pressurized water descaler operating at pressures less than 3500 psi. The water exits the nozzles in a fan fashion. The nozzles are positioned at a distance, on the order of 6–12 inches, from the surface of the metal. Dispensed water contacts the primary scale, which tends to be somewhat exfoliated, and lifts it away from the metal. Water is also trapped in porous pockets in the scale. At these

temperatures, on the order of 1600 degrees Fahrenheit, steam forms quickly and the scale is also dislodged by the rapidly expanding steam.

During cooling of the hot rolled steel, the oxygen in the air again reacts with the metal to form a much thinner and tighter oxide coating. This is referred to as "secondary" scale or post hot rolling scale. The secondary scale is on the order of 0.005 inches thick or less and is dense and uniform in nature. The above-described pressurized water system cannot remove the secondary scale. Therefore, abrasion and/or chemical methods such as pickling must be used. Pressurized water, i.e., water maintained at pressure above 20,000 psi (pounds per square inch) has been used for 10–20 years in applications, such as rock drilling, stripping paint from bridges, metal cutting, cutting of fiber glass circuit boards, and cutting of lumber. More recently, pressurized water has been adapted to more refined applications, such as robotic stripping of paint from airplanes and ships, cleaning electronic circuit boards, CNC machining, cleaning and near net shape machining of metal and ceramic parts. In all these instances the work piece is held stationary and the nozzle, which supplies the high pressure water stream, moves relative to the target.

Work has been carried out by Dr. David Summers at the University of Missouri to develop efficient nozzles for hand-held wands. These hand-held systems have been used at pressures up to 60,000 psi and a flow rate of 1–2 gpm (gallons per minute). Work has also been carried out by the NASA Marshal Space Flight Center (MSFC) where ultra high pressure water has been adopted to robotically move the high pressure nozzle over a stationary object (a reusable rocket booster) to remove left over fuel. Similarly, the Air Force has been testing a robotic system to remove paint from airplanes. MSFC has also been experimenting with the injection of a solid abrasive into the high pressure stream to increase the efficiency of the process. The abrasive currently used is made of baking soda (sodium bicarbonate) and the process leaves solids that must be disposed of. A problem with abrasive type system is that the abrasive must be disposed of offsite. This is a costly endeavor.

It is an object of the present invention to provide an improved cleaning method for materials processing with increased productivity.

It is further an object of the present invention to provide a substrate cleaning method that is faster than the prior state of the art, results in a more uniform surface quality than the prior state of the art and minimizes waste.

SUMMARY OF THE INVENTION

One aspect of the present invention utilizes a high pressure slurry of ice and water directed toward a moving substrate to clean a surface of the substrate. The present invention omits the use of chemicals, thereby significantly reducing the risk to the environment. Further, the present invention provides various advantages over traditional chemical cleaning methods, such as simplification of the process, improvement in efficiency, improved surface quality, improvement of the work environment and reduced energy costs. The present invention provides an advantage over current high pressure cleaning systems utilizing solid abrasive injection by using ice particles in the cleaning fluid as the abrasive. Furthermore, the present invention eliminates the need to dispose of or recycle the leftover solids of the chemical cleaning solution. The prior art systems include leftover solids are often mixed with hazardous waste and, subsequently, must be treated as a hazardous waste.

Another aspect of the present invention is a pressurized water cleaning method for materials processing and manufacturing, that includes the steps of:

(a) conveying or moving a product having a surface through a set of fixed nozzles or spray headers; and

(b) directing a pressurized stream of cleaning fluid toward the surface of the product. Preferably, the cleaning fluid is water. The stream may include ice particles. Preferably, the pressurized stream is in the range of 10,000 psi (pounds per square inch) to 120,000 psi. By pressurized stream it is meant that the supply of pressurized liquid to a nozzle prior to the liquid exiting the nozzle in a stream at approximately atmospheric pressure.

The moving product may be in the form of a strip, sheet, rod, wire, bar or filament. The materials may be carbon steel, stainless steel, titanium, brass, copper, bronze, Inconel, aluminum, glass, kevlar, polymer, fiberglass, or foam. Essentially, the process may be used on all materials and materials systems where the surface layers are required to be removed. This could apply to oils and greases on any substrate, surface oxides on metallic substrates, and protective coatings on metals, paints, polymers or ceramics. Generally, the present invention can be used where an undesirable coating or film, solid or liquid, needs to be removed from a substrate.

The present invention is also an arrangement for cleaning materials that includes a conveyor for transporting a product or target material having a surface and a set of nozzles or spray header positioned to direct a high pressure stream of cleaning fluid toward the product surface as the product is positioned on the conveyor. Preferably, the product travels at a speed of ten (10) feet per minute (fpm) to five hundred (500) feet per minute (fpm). Preferably, the cleaning fluid flows at a volumetric flow rate of one (1) gallon per minute to fifty (50) gallons per minute per nozzle and more preferably one gallon per minute to twenty (20) gallons per minute. A set of spray headers are positioned above and below the target material or product to clean the respective surfaces. The spray headers are configured to direct pressurized cleaning fluid onto the surface of the product. A nozzle or a set of nozzles are coupled to the spray headers to deliver a stream of pressurized cleaning fluid towards the respective surfaces. The nozzles may be single or multiple orifice nozzles and may supply a cylindrical stream or a fanned stream of cleaning fluid. The nozzles may be fixed, but preferably the nozzles rotate about a longitudinal axis of the nozzle.

A refrigeration system may be provided to generate small ice particles in the cleaning fluid prior to exiting the spray headers. The ice particles in combination with water exiting the nozzle form an ice water mixture where the ice acts as an abrasive when it contacts the product surface. Preferably, ice is injected into the cleaning fluid when necessary.

A fluid pump is in fluid communication with the spray headers to supply ultra high pressure cleaning fluid to the headers. The pressures supplied by the pump may be in the range of 10,000 psi to 120,000 psi. Preferably, the flow rate generated by the pump may be between one (1) and fifty (50) gpm and the spray headers have a maximum width of eighty (80) inches. The conveyance speeds may range from ten (10) feet per minute (fpm) to five hundred (500) fpm.

The present invention is believed to be particularly well suited to clean oxides, especially secondary scale, from metal substrates, such as steel, copper alloys, aluminum, and titanium alloys. It is also believed to be well suited to remove protective coatings such as paint or zinc from a coiled substrate. The present invention is applicable for cleaning any type of films, such as grease or paint from metal or nonmetallic substrates.

More specifically, the present invention is a material cleaning system that includes a conveyor for moving a substrate in a first direction and at least one nozzle positioned away from the substrate. A pressurized fluid supply is in fluid communication with the nozzle. The nozzle is arranged so that the pressurized fluid exits the nozzle and is directed to a surface of the substrate for removing a liquid or a solid film from the substrate. Preferably, the pressure of the fluid prior to exiting the nozzle is on the order of 10,000 psi to 120,000 psi and, more preferably, 40,000 psi to 60,000 psi. Preferably, a plurality of nozzles are provided with a header and arranged over the conveying arrangement. Preferably, a reel system is used to convey the substrate in close proximity to the nozzles. Alternatively, any type of conveying system may be used, for example, rotary tables, rotating spindles, reel-to-reel take up, etc. The pressurized fluid is accomplished through a crank type pump, a piston pump, or any other pump capable of generating the necessary pressures and volumes.

In another embodiment of the present invention, a pressurized mixture of ice and water can be provided to the nozzles. A high velocity stream of the mixture contacts a surface of the substrate, thus removing a film coating on the substrate.

The present invention is also a method for removing a coating on a substrate that includes the steps of:

(a) providing a pressurized fluid to a stationary nozzle, which may be multi-ported and rotate or oscillate about an axis;

(b) directing the pressurized fluid from the nozzle in a high velocity fluid stream towards a moving object having a surface coating; and

(c) contacting the fluid stream with the object, whereby a force of the fluid removes the coating. Preferably, the fluid is water. More preferably, the fluid is a mixture that includes an abrasive. Most preferably, the mixture is made up of ice and water.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic view of a cleaning system made in accordance with the present invention;

FIG. **2** is a schematic view of the cleaning system shown in FIG. **1** in more detail;

FIG. **3** is a perspective view of the cleaning system schematically shown in FIGS. **1** and **2**;

FIG. **4** is a schematic view of another embodiment of the cleaning system shown in FIG. **3**;

FIG. **5** is an elevational view of a portion of the cleaning system shown in FIG. **3**;

FIG. **6** is an elevational view of a portion of the cleaning system made in accordance with the present invention showing a nozzle, water stream and substrates; and

FIG. **7** is an elevational view of a nozzle used in the present invention showing three physical states of water exiting therefrom.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** is a schematic showing a cleaning system **10** made in accordance with the present invention. Specifically, the cleaning system **10** includes a pressurized supply of water

12 in fluid communication with a conduit 14. The conduit 14 is in fluid communication with a plurality of nozzles 16. The nozzles 16 are arranged so that the pressurized fluid (preferably water) exits the nozzles in a high velocity stream 18 to contact a substrate 20 having a coating, such as an oxide coating or grease coating on a substrate of metal or non-metallic material, such as plastic.

FIG. 2 shows the cleaning system shown in FIG. 1 in more detail. A water supply 22 is in fluid communication with a conduit 24. The conduit 24 is in fluid communication with a high pressure (HP) pump 26. The high pressure pump 26 is in fluid communication with a conduit 28. The conduit 28 is in fluid communication with a spray header 30 containing a plurality of nozzles 32. The nozzles are arranged so that the pressurized fluid exits the nozzles at a high velocity stream 34 to contact a moving substrate 36 having a coating.

FIG. 3 in accordance with this invention shows a cleaning system spray header 38 with a plurality of nozzles 40 arranged so that the pressurized fluid (preferably water) exits the nozzles as a high velocity stream 42 to contact a substrate 44 that is being moved by a conveying system 46.

FIG. 4 shows another embodiment of the present invention and includes a water supply 48 in fluid communication with a conduit 50. The conduit 50 is in fluid communication with a high pressure pump 52, such as the pumps previously described. The pump is in fluid communication with a conduit 58. A system for making an ice slurry or mixture 54 is provided. This system 54 includes a refrigeration unit and a pump, such as a screw pump. The system to make an ice slurry 54 is in fluid communication with the conduit 58, through a conduit 56. The conduit 58 is in fluid communication with a branching conduit 60 having an upper portion and a lower portion. The lower portion of the branching conduit 60 is in fluid communication with a bottom spray header 62 and an upper spray header 62'. The spray headers are provided with a plurality of nozzles for directing the cleaning fluid toward a substrate. A coiler 66 is positioned on one side of the spray headers 62 and 62' and an uncoiler 68 is positioned on another side of the spray headers 62 and 62'. A substrate 70, such as a metal strip, is wound around the coiler 66 and uncoiler 68. The metal strip 70 includes a film, such as grease or oxides, on its outer surfaces 71 and 73. The nozzles of the spray headers 62 and 62' direct the high pressure water with ice mixture toward the metal strip or substrate 70 for removal of the coating. The pressurized water exits as a high velocity stream and then contacts the moving metal strip 70. Contact of the high velocity water and ice mixture causes the coating to be removed.

FIG. 5 shows the mechanics of the removal of a coating from a substrate in more detail. Specifically, FIG. 5 shows a substrate 80, such as the metal strip 70, shown in FIG. 4, having a coating 82, such as an oxide coating or grease coating. A high velocity fluid stream 84 is directed at the substrate 80 at a contact point 86. The stream 84 contacts the substrate surface 88 at an angle α. The substrate 80 travels in a direction X opposite the direction of the liquid stream 84. The liquid stream can be a mixture of ice and water. After the liquid stream 84 contacts the substrate surface 88 and the coating 82, coating particles 90 are carried away by the stream 84, thereby exposing the surface of the base material.

Preferably, water is used as the cleaning solution. The pressures of the water supplied by the pump preferably are in the range of 10,000 psi to 120,000 psi and, more particularly, 40,000 to 60,000 psi. Preferably, the flow rate of the pump may be between one (1) and fifty (50) gallons per minute and more preferably between twelve (12) and twenty (20) gallons per minute. Preferably, the spray headers have a maximum width of 80 inches so that a standard steel strip can be cleaned. The high pressure fluid, i.e., water, can be accomplished through a crank type pump, a piston pump, or any other pump capable of generating the necessary pressures and flow rates. One type of pump that can attain these high pressures is Model D1500-40 manufactured by New Jet Technologies of Seattle, Wash.

An important aspect of the present invention is that the substrate is conveyed by conveyors relative to the nozzles. FIG. 3 shows a plurality of driven rollers 46 as the conveyor. Other types of conveying arrangements can be used, such as a reel system as shown in FIG. 4 or rotary tables, rotating spindles, reel-to-reel take up, etc.

The nozzles for directing the liquid toward the moving substrate are specifically designed for high pressure fluid applications. Nozzles can direct the high pressure fluid in a straight high velocity line or a fanned stream. The nozzles may be fixed to the header or not rotate or they may rotate about a longitudinal axis of the nozzle, as shown in FIG. 3.

The present invention is believed to be well suited to clean oxides from metal substrates, such as steel, copper alloys, aluminum and titanium alloys. It is also believed to be well suited to remove protective coatings, such as paint or zinc from a sheet or a coiled substrate. Furthermore, it is believed that the present invention is well suited for removing greases and other organic coatings on a substrate, such as steel. Also, the present invention is believed to be well suited for the removal of similar coatings on non-metallic material, such as plastic.

Preferably, the present invention utilizes an intermediate pressure of water or liquid higher. By definition intermediate pressures are 5,000 psi–20,000 psi, very high pressures of water 20,000 psi–60,000 psi, and ultra high pressures at greater than 60,000 psi. The present invention can operate at all of these pressure ranges and preferably 5,000 psi–120,000 psi. Preferably, the present invention is used to remove scale from rolled metal and most preferably secondary scale, which is a metal oxide, although the present invention can also be used to remove primary scale. Preferably, the water exits a rotating or oscillating nozzle as shown in FIG. 6. FIG. 6 shows a nozzle 100 which is in fluid communication with the spray header 62, in a high pressure source of water shown in FIG. 4. The nozzle 100 is adapted to rotate about an axis 102 so that a stream of water 104 contacts an area of a substrate, such as steel, 106 to remove an oxide coating, such as a secondary coating. Preferably, the water pressure supplied to the nozzle is in the range of 5,000–120,000 psi; the angle of attack α as shown in FIG. 6 is between 90° and 75° as measured from the surface of the substrate 106 where the stream of water 104 contacts the substrate 106 or 0°–15° as measured from a vertical axis normal to the surface of the substrate 106 where the stream of water 104 contacts the substrate 106; the volume of water flowing through the nozzle is between 1–20 gallons per minute (GPM), preferably 6–20 gallons per minute (GPM); and the velocity of water exiting the nozzle is on the order of two thousand feet per second or more at a stream diameter between 0.03 inches and 0.065 inches. One such nozzle is provided as the ultra high pressure (UHP) GUN, Model # UPSG-40 manufactured by Underpressure Systems, Inc. in which the stream of water exits at 3,000 feet per second and the pressure of the pressurized water is on the order of 60,000 psi. The substrate moves in the horizontal direction 108 relative to the nozzle 100 and the nozzle rotates about axis 102 relative to the substrate 106. Preferably, the nozzle rotates or oscillates at 50–5,000 RPM (revolutions per minute). Preferably, the

nozzle 100 includes a plurality of ports, of which only one is shown in FIGS. 6 and 7, and oscillates or rotates about the axis 102 wherein a high velocity water stream 104 exits from each of the ports, so that each of the fluid streams contact the object, whereby the force of the fluid from each of the fluid streams removes the coating on the substrate 106.

FIG. 7 shows the nozzle 100 having a stream of high velocity water 104. The water stream 104 has three zones: zone one 110 is known as the coherent where the water stream has the highest energy; zone two 112 is known as the unstable zone, where the water stream begins the fade out and lose energy; and zone three 114, the dispersion zone, where the water stream 104 breaks into droplets and has the least amount of energy. In the case of primary scale, the waterdrop forms of zone three 114 will suffice to remove the scale. However, dispersion will not remove secondary scale. Therefore, the nozzle tip 116 must be positioned close to the substrate so that the water stream 104 contacts the substrate in the unstable zone, i.e., metastable zone, or within the coherent zone. Preferably, the nozzle tip 116 is positioned between ½–2 inches away from the substrate surface, which based upon the above-identified parameters, results in a water stream that is either in the coherent zone 110 or unstable zone 112 but not in the dispersion zone 114. The coherent zone occurs within a distance X, from the nozzle tip 116; the unstable zone occurs between a distance X_1 and X_2 from the nozzle tip 116; and the dispersion zone occurs a distance greater than a distance X_2. These distances X_1, X_2, and X_3 are defined by various factors, such as the initial water stream diameter and the supply pressure of the water to the nozzle.

Although the present invention has been described in detail in connection with the discussed embodiments, various modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the present invention. Therefore, the scope of the present invention should be determined by the attached claims.

What is claimed is:

1. A method for removing a coating on a substrate, comprising the steps of:

(a) providing a pressurized fluid to a stationary nozzle;

(b) directing the pressurized fluid from the nozzle in a high velocity fluid stream toward a moving object having a coating, wherein the velocity of fluid stream is over 1,000 feet per second; and

(c) contacting the fluid stream with the object, whereby a force of the fluid removes the coating.

2. The method as claimed in claim 1, wherein the fluid is water.

3. The method as claimed in claim 2, further comprising providing an abrasive with the water prior to exiting the nozzle, so that the exiting high velocity fluid stream includes an abrasive.

4. The method as claimed in claim 3, wherein said abrasive is ice.

5. A method as claimed in claim 1 wherein the object is metal.

6. A method as claimed in claim 1, wherein the coating is scale.

7. A method as claimed in claim 6, wherein the scale is a secondary scale.

8. A method as claimed in claim 1, wherein the coating is an oxide.

9. A method as claimed in claim 1, wherein the stationary nozzle rotates about an axis relative to the object.

10. A method as claimed in claim 1, wherein the high velocity stream exits at an angle α relative to the object.

11. A method as claimed in claim 1, wherein the water stream contacts the object in one of a coherent zone and a metastable zone.

12. A method as claimed in claim 1, wherein the object is rolled metal and the coating is secondary scale, wherein the high pressure fluid is provided in the range of 5,000 psi to 120,000 psi, the velocity stream contacts the object at an angle of 0° to 15° as measured from a vertical axis normal to a surface of the object whereby the velocity stream contacts the object, and the volume of water passing through the nozzle is between one and twenty gpm.

13. A method as claimed in claim 1, wherein the nozzle comprises a plurality of ports and ocillates about an axis, wherein a high velocity fluid stream exits from each of the ports so that each of the fluid streams contact the object whereby the force of the fluid from each of the fluid streams removes the coating.

14. A material cleaning system comprising:

a conveyor for moving a substrate in a first direction;

at least one nozzle positioned away from said conveyor and positioned to direct a stream of fluid toward the conveyor; and

a pressurized fluid supply in fluid communication with the nozzle, wherein the pressurized fluid supply is arranged to supply a pressurized fluid to exit the nozzle and direct the fluid at a high velocity of over 1,000 feet per second to a surface of the substrate for removing a liquid or solid film from the substrate.

15. The material cleaning system as claimed in claim 14, wherein the pressurized fluid supply comprises a pump for pressurizing a fluid.

16. The material cleaning system as claimed in claim 15, wherein the pump pressurizes the fluid supply on the order of 5,000 to 120,000 psi.

17. The material cleaning system as claimed in claim 16, wherein the pump pressurizes the fluid supply to a pressure of 40,000 psi to 60,000 psi.

18. The material cleaning system as claimed in claim 14, wherein the conveyor includes one of a rotary table, rotating spindles, and a reel-to-reel take up.

19. The material cleaning system as claimed in claim 14, further comprising a plurality of nozzles attached to a header which is in fluid communication with the high pressure fluid supply.

20. The material cleaning system as claimed in claim 14, further comprising means for supplying ice to the high pressure fluid supply for forming a mixture of ice and fluid to be supplied to the nozzle.

21. A method for removing scale from a rolled metal product comprising the steps of:

(a) providing a pressurized fluid to a stationary nozzle, wherein said fluid comprises water;

(b) directing the pressurized fluid from the nozzle in a high velocity fluid stream toward a moving rolled metal having scale on a surface of the metal, wherein the velocity of the fluid is over 1,000 feet per second; and

(c) contacting the fluid stream with the surface, of the metal whereby a force of the fluid removes the scale, wherein the fluid is pressurized to a pressure between 5,000 psi and 120,000 psi.

22. A method as claimed in claim 20, wherein said scale is secondary scale.

23. A method as claimed in claim 20, wherein said scale is scale formed subsequent to the formation of primary scale.

24. A method as claimed in claim 20, wherein said scale is an oxide formed at elevated temperatures.

25. A method for removing secondary scale on rolled metal, comprising the steps of:

(a) providing a high pressure fluid to a stationary nozzle wherein the high pressure fluid is provided in the range of 5,000 psi to 120,000 psi;

(b) directing the high pressure fluid from the nozzle in a high velocity fluid stream toward moving rolled metal having secondary scale; and

(c) contacting the fluid stream with the object, whereby a force of the fluid removes the secondary scale, wherein the velocity stream contacts the object at an angle of 0° to 15° as measured from a vertical axis normal to a surface of the rolled metal whereby the velocity stream contacts the rolled metal, and the volume of water passing through the nozzle is between one and twenty gpm.

26. A method for removing a coating on a substrate, comprising the steps of:

(a) providing a pressurized fluid to a stationary nozzle;

(b) directing the pressurized fluid from the nozzle in a high velocity fluid stream toward a moving object having a coating; and

(c) contacting the fluid stream with the object, whereby a force of the fluid removes the coating, wherein the nozzle comprises a plurality of ports and ocillates about an axis, wherein a high velocity fluid stream exits from each of the ports so that each of the fluid streams contact the object whereby the force of the fluid from each of the fluid streams removes the coating.

27. A method for removing a coating on a substrate, comprising the steps of:

(a) providing a pressurized fluid to a stationary nozzle;

(b) directing the pressurized fluid at a pressure of over 5,000 psi from the nozzle in a high velocity fluid stream toward a moving object having a coating; and

(c) contacting the fluid stream with the object, whereby a force of the fluid removes the coating.

28. A method for removing coating on a substrate as claimed in claim 27, wherein the pressurized fluid is provided at a pressure between on the order of 5,000 psi to 120,000 psi.

29. A material cleaning system comprising:

a conveyor for moving a substrate in a first direction;

at least one nozzle positioned away from said conveyor and positioned to direct a stream of fluid toward the conveyor; and

a pressurized fluid supply in fluid communication with the nozzle, wherein the pressurized fluid supply is arranged to supply a pressurized fluid to exit the nozzle and direct the fluid at a high velocity to a surface of the substrate for removing a liquid or solid film from the substrate, wherein the nozzle comprises a plurality of ports and ocillates about an axis, wherein a high velocity fluid stream exits from each of the ports so that each of the fluid streams contact the object whereby the force of the fluid from each of the fluid streams removes the coating.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,273,790 B1
DATED : August 14, 2001
INVENTOR(S) : Edward D. Neese et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1,
Line 60, "0.050 inches" should read -- 0.050 inch --.

Column 2,
Line 8, "0.005 inches" should read -- 0.005 inch --.
Line 32, "left over fuel" should read -- leftover fuel --.
Line 66, after "solids" insert -- which --.

Column 6,
Line 58, "0.03 inches" should read -- 0.03 inch --.
Line 59, "0.065 inches" should read -- 0.065 inch --.

Column 8,
Line 15, "contact" should read -- contact --.
Line 62, "in claim 20" should read -- in claim 21 --.
Line 64, "in claim 20" should read -- in claim 21 --.
Line 66, "in claim 20" should read -- in claim 21 --.

Column 10,
Line 26, "contact the object" should read -- contacts the object --.

Signed and Sealed this

Thirtieth Day of April, 2002

Attest:

JAMES E. ROGAN

Attesting Officer *Director of the United States Patent and Trademark Office*

US005716264A

United States Patent [19]

Kimura et al.

[11] Patent Number: 5,716,264
[45] Date of Patent: Feb. 10, 1998

[54] POLISHING APPARATUS

[75] Inventors: Norio Kimura, Kanagawa-ken; Ritsuo Kikuta, Chiba-ken; You Ishii; Masayoshi Hirose, both of Kanagawa-ken, all of Japan

[73] Assignee: Ebara Corporation, Tokyo, Japan

[21] Appl. No.: 683,424

[22] Filed: Jul. 18, 1996

[30] Foreign Application Priority Data

Jul. 18, 1995 [JP] Japan 7-203906

[51] Int. Cl.6 .... B24B 21/18
[52] U.S. Cl. 451/443; 451/41; 451/60; 451/285; 451/286; 451/287; 451/288; 451/289; 451/290
[58] Field of Search 451/285–290, 451/443, 41, 60; 134/153, 144

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Primary Examiner—Robert A. Rose
Assistant Examiner—George Nguyen
Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57] ABSTRACT

A polishing apparatus is employed to polish an object to be polished by urging the surface of the object to be polished against the surface of a polishing cloth and causing a relative movement therebetween, while supplying a polishing liquid into an area between the object to be polished and the polishing cloth. A plurality of nozzles spray respective fluid jets to strike against the surface of the cloth. The plurality of nozzles include more than one type of nozzle which vary flow velocity, flow rate, angle of spray, and cross-sectional configuration of a jet. The plurality of nozzles have axes positioned at a location at different distances from the rotation axis of the polishing cloth.

59 Claims, 6 Drawing Sheets

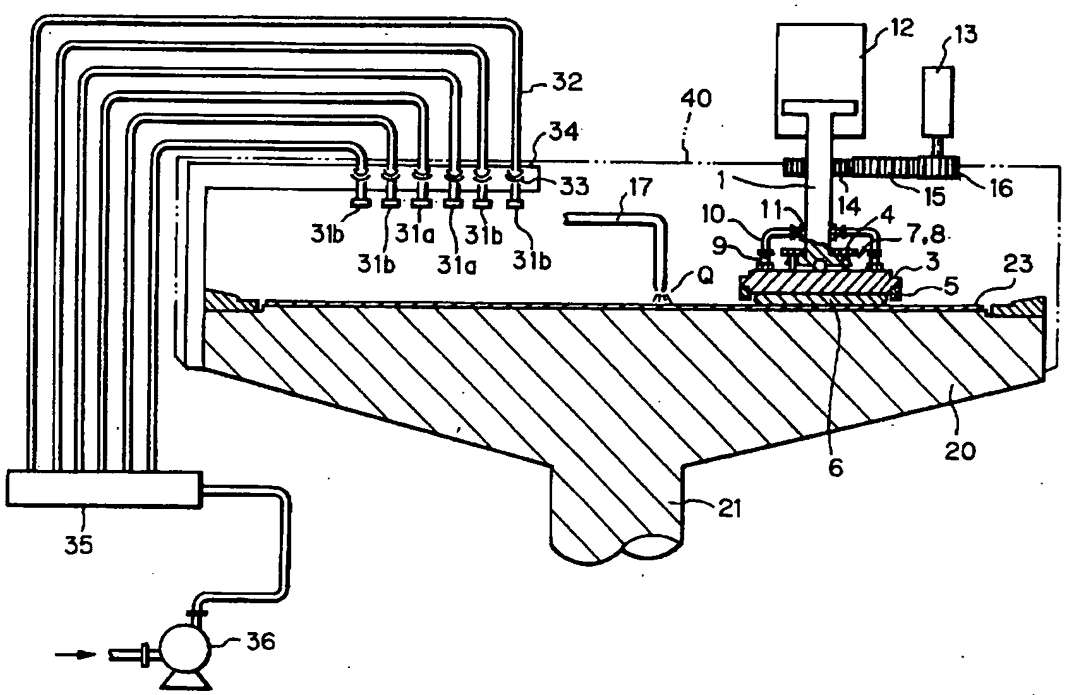

Fig. 1

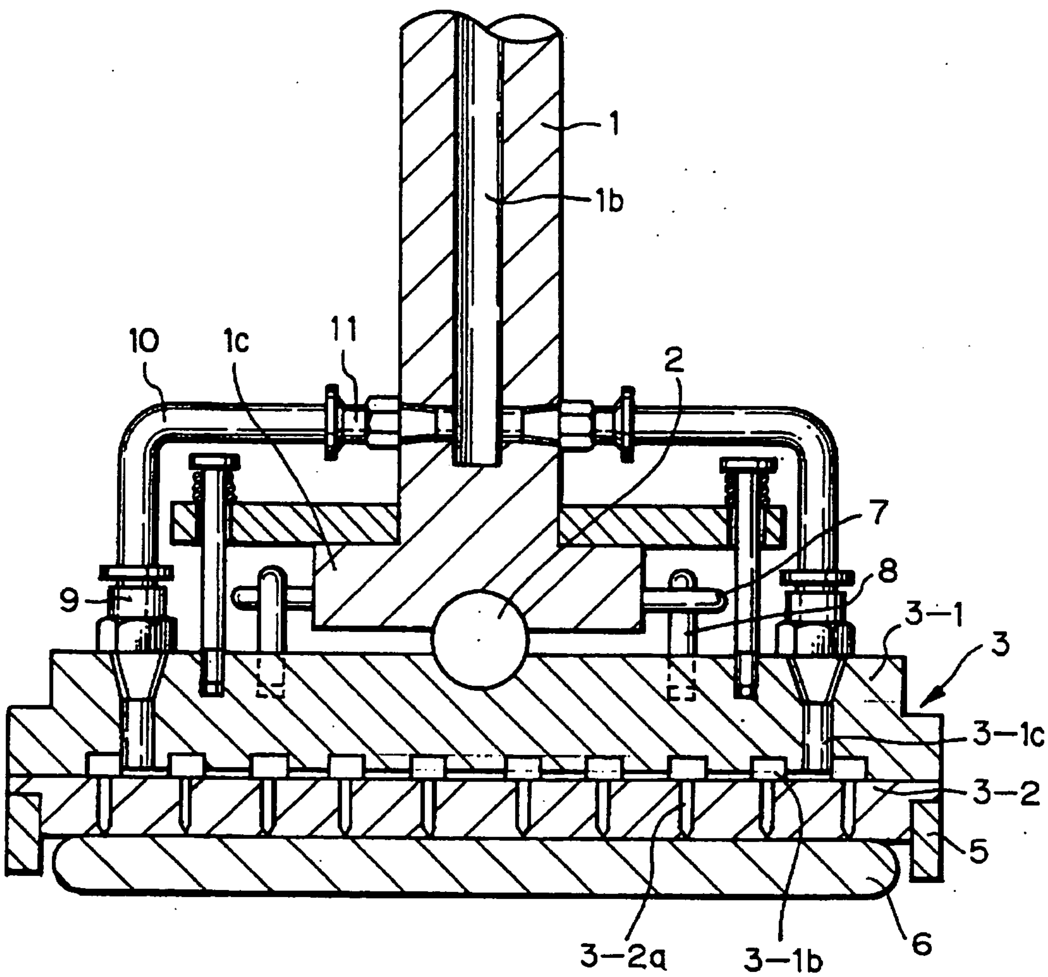

Fig. 2

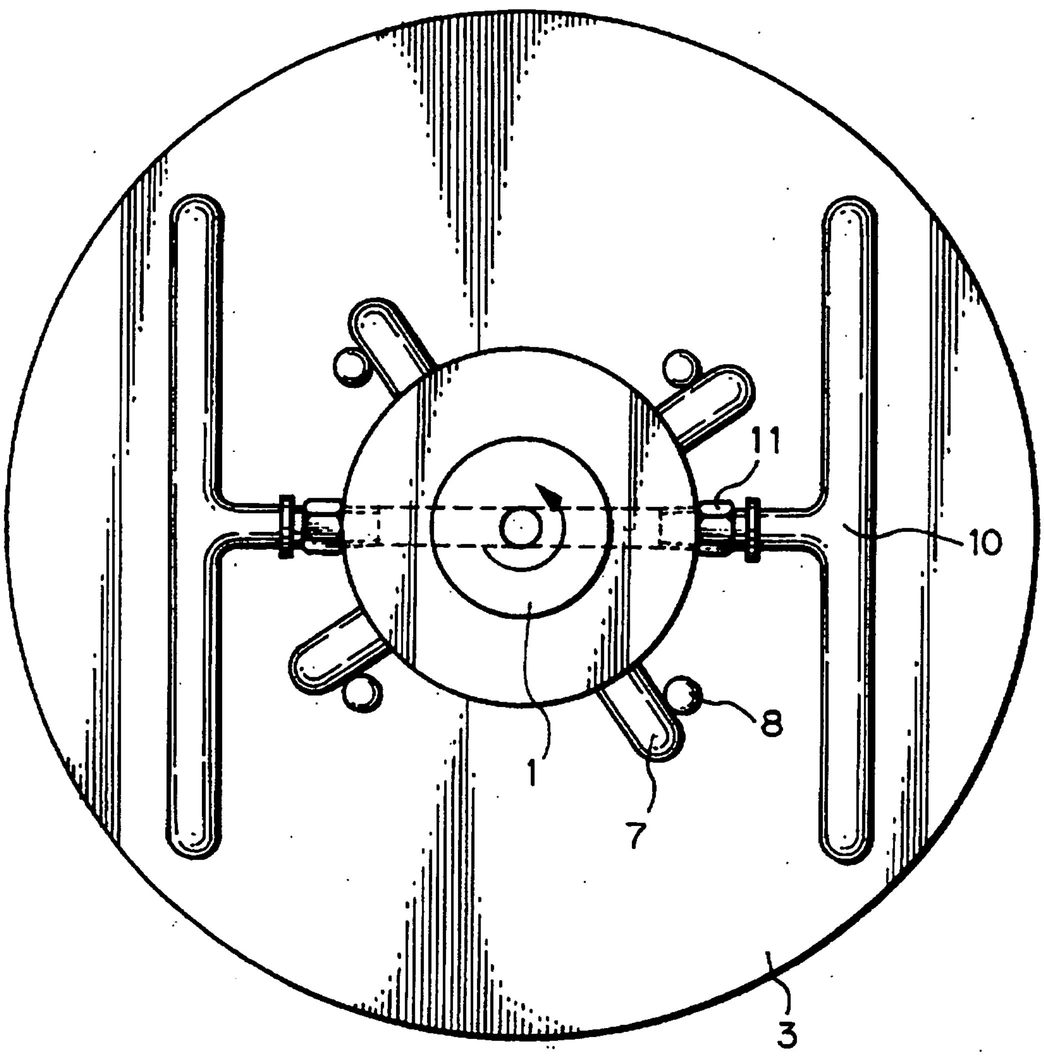

Fig. 3

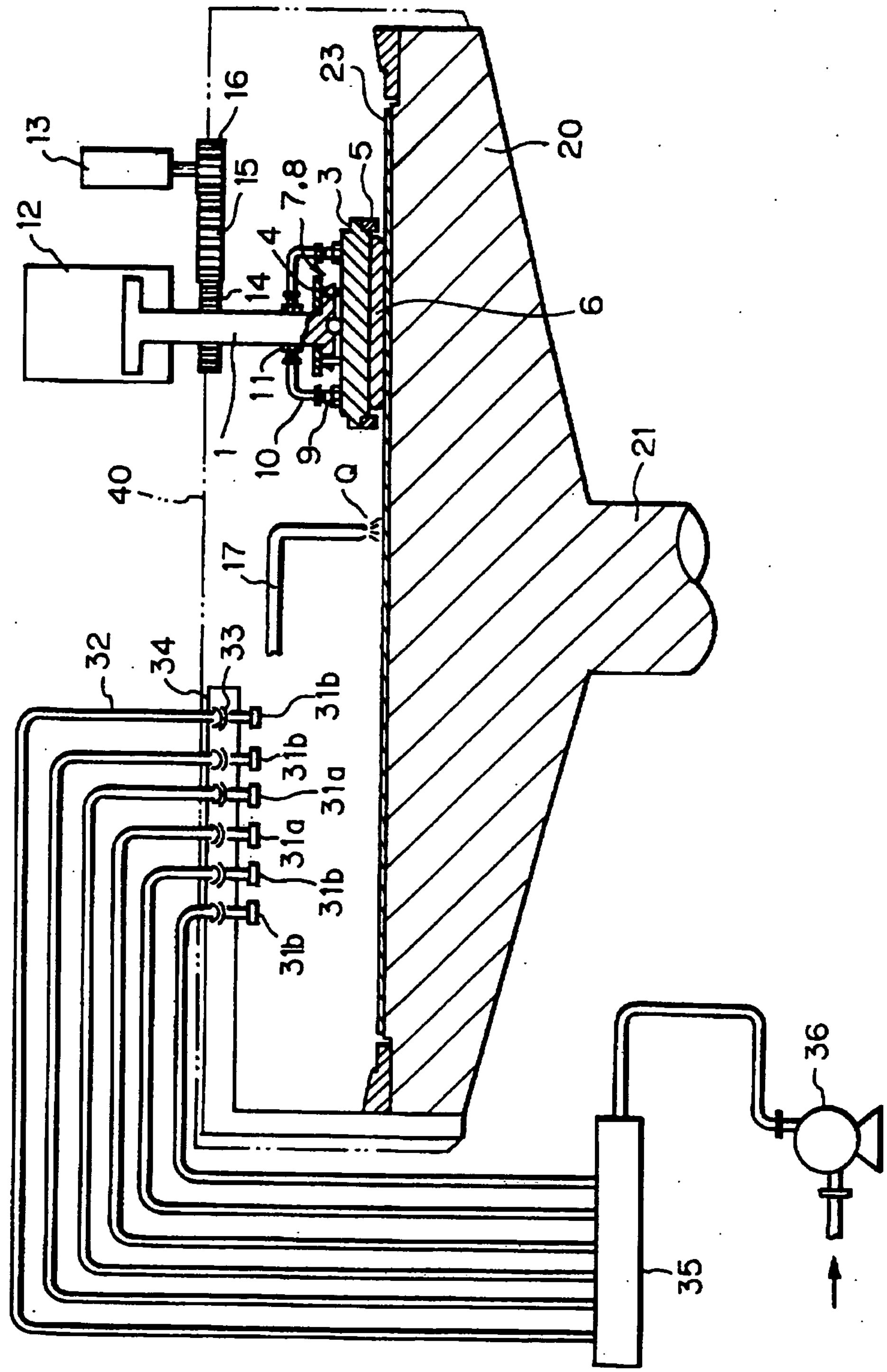
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Fig. 4

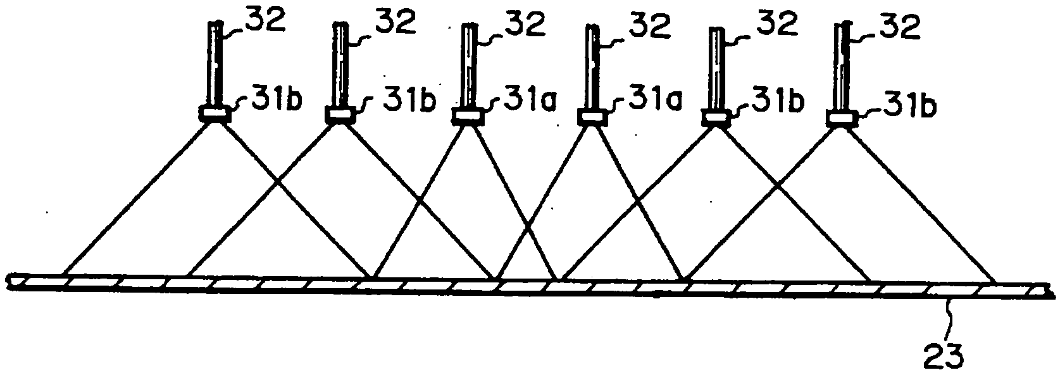


Fig. 5

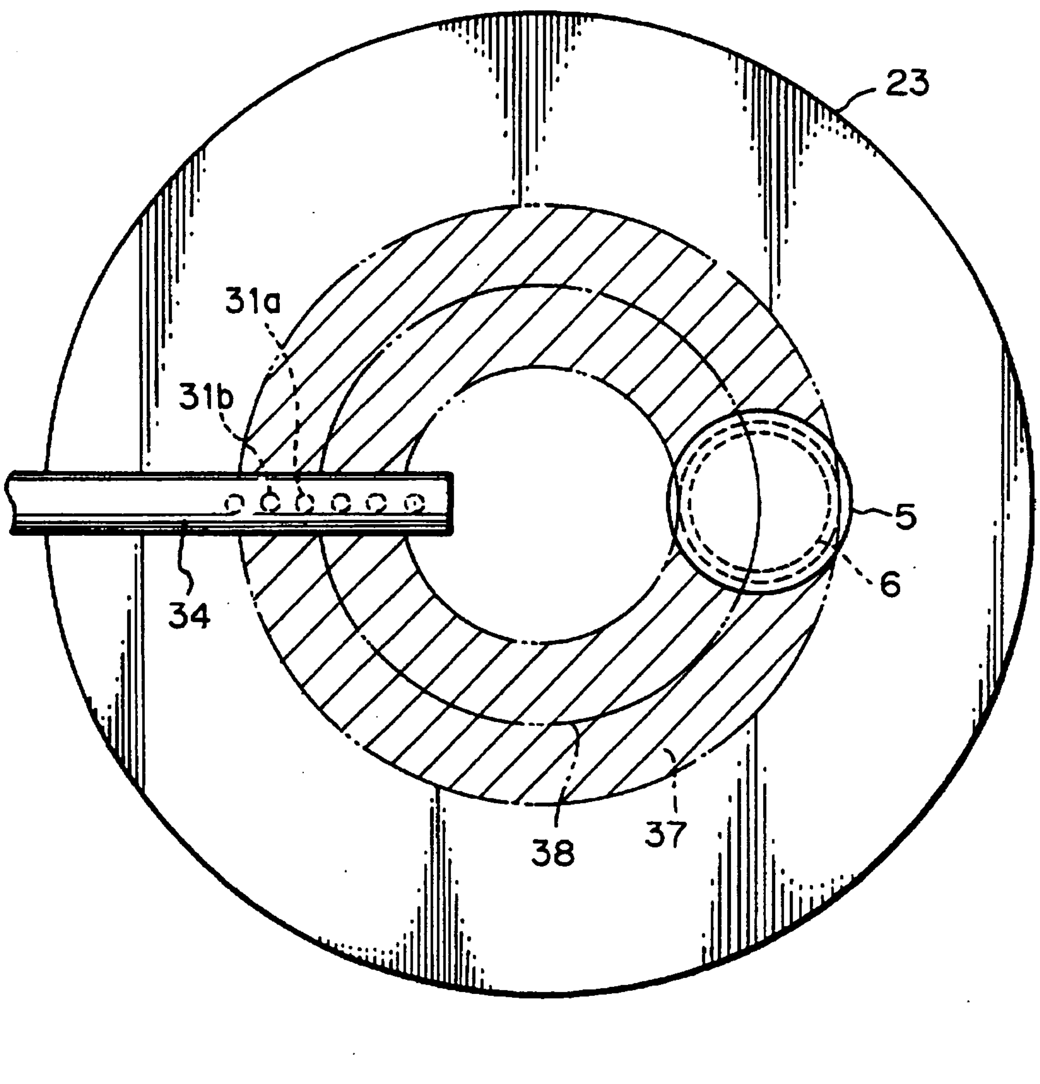


Fig. 6a

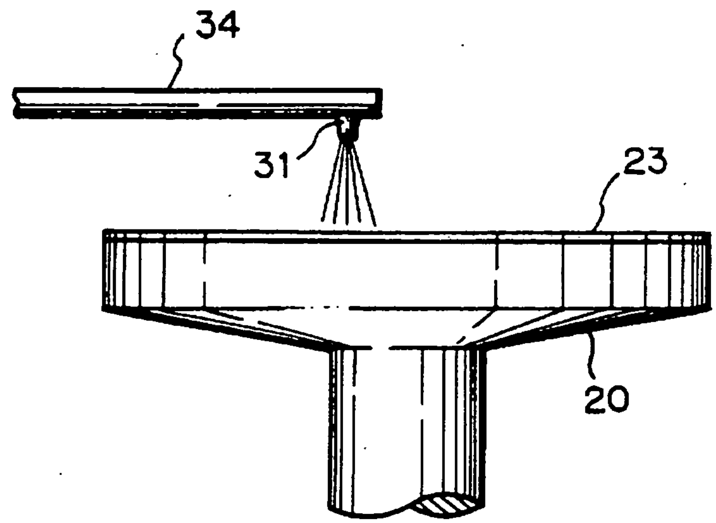
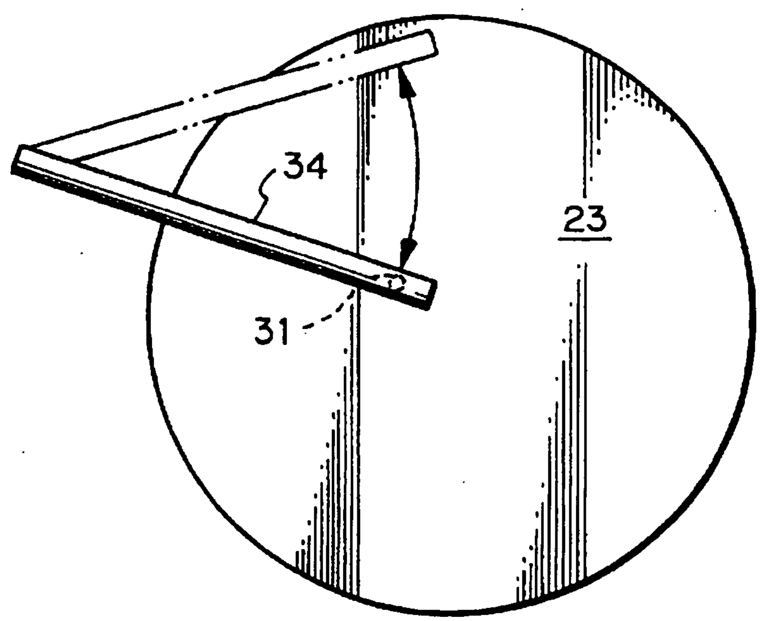


Fig. 6b



POLISHING APPARATUS

BACKGROUND OF THE INVENTION

1. (Field of the Invention)

The present invention relates to a polishing apparatus for polishing an object such as a semiconductor wafer and the like that is required to be polished into a flat mirror-like configuration an including a polishing cloth provided on a turntable, and more particularly to such a polishing apparatus which provides an optimum dressing operation of the polishing cloth.

2. (Prior Art)

With the increasing use of highly integrated circuits such as LSI and VSLI, etc., inter-linear distances in circuits have become increasingly short. Industry thus is using light sources having a shallower focal depth in comparison to the prior art in a lithograph operation for forming a circuit. The use of a shallow focal depth light source has brought about a demand for wafers having surfaces with increased flatness. Additionally, with the evolution of multi-layered configurations, wafers have to have a substantially even surface after individual layers are formed. A polishing apparatus is one means for processing a semiconductor wafer to have a flat surface.

The polishing apparatus comprises a turntable which has a polishing cloth provided on its surface, a top ring for pressing the wafer surface to be polished toward the polishing cloth, and means for feeding an abrasive liquid in which abrasive grains are contained. In this polishing apparatus, the step of flattening the wafer surface, i.e. the polishing step, is carried out by rotating the turntable and the top ring, whereby the wafer retained in position by the top ring is urged against the polishing cloth while abrasive liquid is fed onto the surface of the polishing cloth.

During the polishing operation, abrasive liquid is supplied onto the polishing cloth surface, and the liquid is retained within and upon the surface of the polishing cloth for a certain time interval. The wafer surface is polished by means of the abrasive liquids with the abrasive liquid being replaced with fresh liquid at intervals and discharged out of the turntable.

However, the following problems arise:

1. Abrasive grains in the liquid are progressively reduced in size, and consequently grains with decreased polishing ability may accumulate within the polishing cloth, instead of being discharged.
2. Distribution of abrasive grains in the polishing cloth may not be even.
3. Fibers in the polishing cloth gradually collapse, whereby the cloth loses the capability of retaining abrasive grains.
4. Resiliency of the polishing cloth decreases.

Consequently, the polishing cloth must be renewed at regular intervals by a dressing operation. Conventionally, dressing of a polishing cloth has been carried out by scrubbing the surface of the polishing cloth with a brush, or by spraying a fluid jet against the surface of the polishing cloth.

(Problems to be Solved by the Invention)

However, the polishing cloth may not be sufficiently renewed by such procedures using brushes, such that the polishing rate varies after dressing. Dressing is also carried out by scrubbing the polishing cloth with a plate to which diamond grains are applied. In this case, the polishing cloth has a reduced working life.

Because a fluid jet which is sprayed against the object is a uniform jet, there also arises a problem that the polishing surface may not be sufficiently flat due to an uneven distribution of abrasive grains even after dressing.

The present invention has been made with the above described situation as a background, and the object of the invention is to provide a polishing apparatus which polishes a wafer with the entire surface of a polishing cloth in an even manner.

SUMMARY OF THE INVENTION

(Means for Solving the Problem)

In order to solve the above-described problems, the present invention is characterized in that there is provided a polishing apparatus adapted to polish an object to be polished by urging a surface of the object to be polished against a surface of the polishing cloth and causing a relative movement therebetween, while supplying a polishing liquid into an area between the object to be polished and the polishing cloth. The apparatus includes a dressing system including a plurality of nozzles each being adapted to spray a fluid jet to strike against the surface of the polishing cloth. The plurality of nozzles includes more than one type of nozzle to thereby vary at least one of a flow velocity, flow rate, angle of spray, and cross-sectional configuration of the fluid jet. Axes of the plurality of nozzles are positioned at different distances from a rotational axis of the polishing cloth.

Further, even if the number of nozzles is one or a few, the present invention can also provide an effect similar to one obtained when the above-described plurality of nozzles is used, by allowing the nozzle or nozzles to be movable over the polishing cloth during a dressing operation. Furthermore, the present invention provides a more efficient dressing operation by allowing cavitation bubbles to be blended into a fluid jet, thereby increasing an impact pressure by the collapse of cavitation bubbles.

(Operation)

The operation of the present invention will be described hereinbelow.

By allowing the fluid jet to have a varied flow velocity, flow rate, angle of spray, and cross-sectional configuration in accordance with the present invention, it becomes possible to control a water impact pressure when the jet strikes against the surface of the polishing cloth, as well as a location and an area to be effected by the water impact pressure.

The collision pressure which may be created by the fluid jet when it strikes against the surface of the polishing cloth may be a water impact pressure, and it can be represented by the following equation

$$P=\rho CV$$

where P is the water impact pressure, ρ is the density of fluid, C is the sonic velocity and V is the flow velocity of the fluid as it collides (immediately before collision). This corresponds to the water impact pressure to be provided by the fluid in a unit area. The volume may be greater or smaller, depending on whether the flow rate is more or less. The flow volume may be great when the total amount of water impact pressure is great.

The volume of fluid per unit surface area and unit time of the total water impact pressure next will be described in the context of impact pressure. Variation in the angle of spray of the fluid jet and its cross-sectional configuration means that

the jet may be sprayed against a different portion of the cloth surface where its configuration and surface area vary. Generally, if the jet is supplied from the same fluid source, the effect may occur that the greater the angle of the spray, i.e., the more the cross-sectional configuration of the spray diverges, the smaller the impact pressure per unit surface area is. Conversely, the narrower the cross-sectional configuration is, the greater the impact pressure per unit area will be.

Further, the fluid source which is provided for respective nozzles can be used to adjust the jet, rather than varying the distribution of the jet through use of different nozzles. This alternative approach may result in an increase in energy in the fluid source, causing a greater impact pressure on the surface of the cloth. An orifice or a valve provided between the fluid source and the respective nozzle may adjust the jet, restricting the orifice or the valve resulting in a lower impact pressure.

From the above-description, it will be understood that the possible distribution of an impact pressure over the surface of a polishing cloth may be controlled by selecting a nozzle type, etc., in accordance with the present invention.

On the other hand, there still remain several problems which must be overcome by the dressing operation, including abrasive grains being left in an uneven pattern, and fibers collapsing in an uneven manner. Consumed abrasive grains occur in greater volume at the center of an area to be used in a polishing operation, or at an area adjacent to a central trajectory of the center of the top ring on the cloth surface. Thus, from the viewpoint of removal of abrasive grains which remain, increasing the impact pressure of the fluid jet causes more abrasive grains to be discharged. As for the recovery of cloth which has been compressed, results vary depending on the structure and type of the cloth.

Accordingly, selection of a nozzle is generally made such that the fluid jet may strike with a greater impact pressure an area adjacent to a central area which is used in a polishing operation and in which used abrasive grains tend to collect. It is also possible to control impact pressure depending on the polishing conditions, etc. Even if a single or a reduced number of nozzles is used, control may be effected in a similar manner as that when a plurality of nozzles is employed, by allowing the nozzle or nozzles to move above the polishing cloth during the dressing operation. Moreover, by varying the rotating velocity of the turntable upon which the polishing cloth is applied during the dressing operation, finer control may be achieved. Furthermore, if cavitation bubbles are blended into the fluid jet, an increased impact pressure may be obtained from collapse of the bubbles, and consequently a more effective dressing operation may be achieved.

Further, in accordance with the present invention, splashing of liquid is prevented which would otherwise occur when the fluid jet is used to dress the polishing cloth. Moreover, use of the fluid jet is facilitated by using water as a fluid jet stream.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a longitudinal cross-sectional view showing a polishing portion in the polishing apparatus in one embodiment of the present embodiment;

FIG. 2 is a plan view of the polishing portion in the polishing apparatus in one embodiment of the present embodiment;

FIG. 3 is a longitudinal cross-sectional view showing the general arrangement of the polishing apparatus in one embodiment of the present embodiment;

FIG. 4 is a view showing a nozzle array in which water nozzles are arranged in one embodiment of the present invention;

FIG. 5 is a plan view showing one embodiment of the present invention;

FIG. 6a is a longitudinal cross-sectional view showing an alternative embodiment of the present invention and

FIG. 6b is a longitudinal cross-sectional view showing an alternative embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

One embodiment of the polishing apparatus in accordance with the present invention will be described hereinbelow. FIGS. 1 and 2 are views showing the polishing section of the polishing apparatus for use with semiconductor wafers, in which FIG. 1 is a longitudinal cross-section and FIG. 2 is a plan view. The top ring portion of the polishing apparatus comprises a top ring driving shaft 1, a top ring 3, and a ball bearing 2 which is interposed between the top ring driving shaft I and the top ring 3.

The top ring 3 is formed by the top ring body upper portion 3-1 and the top ring body lower portion 3-2, and ring 5 for preventing removal of the wafer is arranged around the outer periphery of the top ring body lower portion 3-2.

The top ring body lower portion 3-2 is formed at its lower surface with a number of vacuum suction ports 3-2*a*. The top ring body upper portion 3-1 is formed with vacuum grooves 3-1*b* which are in communication with these vacuum section ports 3-2*a*, and these vacuum grooves 3-1*b* are also in communication with four vacuum suction ports 3-1*c* which are defined in the top ring body upper portion 3-1. These vacuum ports 3-1*c* are in communication with a vacuum port 1*b* defined through the central portion of the top ring driving shaft 1 by means of vacuum line tubes 10 and tube joints 11.

The top ring driving shaft 1 is integrally provided with the flange portion 1*c*, and four torque transmitting pins 7 are arranged around the outer periphery of the flange portion 1*c*. The top ring body upper of the top ring 3 is provided at its upper surface with four torque transmitting pins 8 each of which corresponds to a torque transmission pin 7. A semiconductor wafer 6 is contained in a space enclosed by the lower surface of the top ring body lower portion 3-2, the inner periphery of the wafer removal-preventive ring 5 and the upper surface of the turntable (to be described later), and the turntable is caused to rotate simultaneously with the rotation of the top ring driving shaft 1. The resulting rotation torque is transmitted to the top ring 3 through engagement between the torque transmitting pins 7 and 8, and it may turn the top ring 3. At the same time, the surface of the semiconductor 6 is polished to have a flat and mirror-like surface, while allowing the top ring to slide.

FIG. 3 is a view illustrating the general construction of the polishing apparatus in which the polishing portion in FIGS. 1 and 2 is used. In FIG. 3, a reference numeral 20 represents a turntable which is adapted to rotate around the shaft 21. The polishing cloth 23 is applied over the upper surface of the turntable 20.

The turntable 20 is provided at its upper portion with the top ring portion. The top ring driving shaft i is provided at its upper portion with the top ring cylinder 12, and the top ring 3 is adapted to be urged against the turntable 20 with a certain urging pressure by means of top ring cylinder 12. A numeral 13 is a top ring driving motor which is adapted to apply a rotation torque to the top ring driving shaft 1 via

gears 14, 15 and 16. The polishing/abrasive liquid spray nozzle 17 is arranged above the turntable 20, and is adapted to spray a polishing/abrasive liquid Q over the polishing cloth 23 of the turntable 20.

Next, the manner of polishing the wafer by means of the polishing apparatus of the above-described construction will be described.

Description will be made in such a case wherein the semiconductor is an object to be polished.

The semiconductor wafer 6 is applied by vacuum against the lower surface of the top ring body lower portion 3-2. To allow the semiconductor 6 to be sucked against the lower surface of the top ring body lower portion 3-2, air is withdrawn through vacuum-section ports 3-2*a* defined in the top ring body lower portion 3-2 and vacuum port 1*b* defined in the central portion of the top ring driving shaft 1 by a vacuum source. The semi-conductor wafer is applied by vacuum pressure against the lower surface of the top ring 3, from a delivery portion (not shown) which is arranged adjacent to the turntable 20.

Then, after the top ring 3 upon which the semi-conductor 6 is retained is shifted onto the turntable 20, the top ring 3 is lowered to place the semiconductor wafer 6 upon the polishing cloth 23 on the upper surface of the turntable 20. Then, atmospheric air is passed into the vacuum suction ports 3-2*a* by disconnecting the vacuum port 1*b* from the vacuum pressure source. Consequently, the semiconductor 6 is released from the lower surface of the top ring 3, and the semiconductor 6 is adapted to rotate against the lower surface of the top ring 3. By rotating the turntable 20 and the top ring 3, and actuating the top ring cylinder 12 to push the top ring 3 toward the turntable 20, the semiconductor 6 is urged against the polishing cloth 23 mounted upon the upper surface of the turntable 20. A polishing/abrasive liquid Q is caused to flow onto the polishing cloth 23 from the polishing/abrasive liquid spray nozzle 17, and the polishing/abrasive liquid Q is retained in the polishing cloth. Consequently, the polishing/abrasive solution Q reaches the surface (lower surface) of the semiconductor wafer to be polished, and thus the polishing operation may be initiated.

After the polishing operation is completed, the semiconductor wafer 6 is again drawn by vacuum against the lower surface of the top ring 3, and the top ring 3 is caused to shift from the turntable 30 to deliver the semiconductor wafer 6 into a cleaning station and the like.

A mechanism for carrying out a dressing operation will be described. In the apparatus as shown in FIG. 3, water jets are sprayed against the surface of the polishing cloth 23 through nozzles 31*a* and 31*b* which are fixed in position on nozzle support member 34 by means of nozzle fixture 33. A plurality of each of nozzles 31*a* and 31*b* are arranged in spaced positions in a dimensional direction of the polishing cloth 23. Flow velocity, flow rate, angle of spray, and cross-sectional configuration of the nozzles 31*a* and 31*b* vary from each other. Water is pressurized by a pump 36 and is then delivered to tubes 32 corresponding to respective nozzles via a branch pipe 35. Water is then supplied to respective nozzles 31*a* and 31*b* through tubes 32 to be sprayed as jets from the nozzles. The nozzles are arranged and oriented such that water which is sprayed from the nozzles strikes the area on the polishing cloth 23 where polishing is to be carried out, i.e., against which a wafer 6 is urged and polished.

A collision pressure which is generated when a water jet strikes the cloth surface is used as a water impact pressure, and the volume of the water provided is in proportion to its density, flow velocity, spray stream and sonic velocity. Such water impact pressure serves to loosen abrasive grains which have accumulated in the cloth, and such grains are then be discharged together with the water.

A cover 40 may be provided to prevent water from splashing circumferentially as shown by phantom lines in FIG. 3.

FIG. 4 is a view illustrating a difference in the angle of water spray, i.e. a diffusion angle, between nozzles 31*a* and 31*b*. Further, FIG. 5 is a plan view illustrating the area on the polishing cloth where polishing is carried out, in conjunction with the nozzle position. FIG. 5 shows only components necessary for illustration of the invention, omitting those members which are not necessary for explanation. In FIG. 5, the shaded area 37 indicates the area on the polishing cloth where polishing is carried out, and a dotted line 38 indicates a center of the area 37 where polishing is carried out.

The nozzle 31*a* is arranged to spray a water jet against an area close to the center 38 of the area where polishing is carried out, whereas the nozzle 31*b* is arranged to spray a water jet against an area more remote from the center 38 of the area where polishing is carried out. As shown in FIG. 4, the angle of water spray from the nozzle 31*a* is made to be smaller than that of a water jet to be sprayed from the nozzle 31*b*. This difference in the angle of water spray serves to make the water impact pressure from the nozzle 31*a* (magnitude of total water impact pressure per unit area and unit time) to be greater than that sprayed from the nozzle 31*b*. Consequently, the water jet having a greater impact pressure strikes a portion closer to the center 38 in the area in the polishing cloth 23 where polishing is carried out, whereas a relatively reduced water jet strikes a portion remote from the center 38. As a result, the impact jet pressure which strikes a portion closer to the center 38 is made greater than that of a jet which strikes the portion remote from the center 38.

As a polishing operation proceeds, abrasive grains accumulate in the polishing cloth, at an area closer to the center 38 of the area where polishing is carried out, with the volume of grains decreasing relatively as the distance from the center 38 increases. By using nozzles having a varied spray angle in combination as a means for carrying out a dressing operation, it is possible to apply a water jet of greater impact pressure on an area closer to the center of an area where polishing is carried out, with a water jet of reduced impact pressure being applied on an area remote from the center 38 of the area where polishing is carried out. Thus, abrasive grains which have been degraded may be discharged in a more efficient manner, thereby causing the volume of abrasive grains to be distributed evenly in the polishing cloth 23 after a dressing operation is complete.

In relation to the above-described embodiment, microscopic observation of a cloth surface which has been dressed indicates that degraded abrasive grains are discharged in an improved manner. Furthermore, subsequent polishing is more effective than when a conventional method is employed.

In the above-described embodiment, a nozzle array is formed in which a nozzle having a reduced spray angle is provided as a nozzle closer to the center, and a nozzle having a greater spray angle is provided as the nozzle proximate to the end. However, the nozzle proximate to the center may be provided with an increased spray angle, if various polishing conditions are employed. There may be some instances where an impact pressure distribution may be required to be varied from that employed in this embodiment. However,

such variance falls within the scope of the present invention, whereby an impact pressure may be distributed in a manner different from that described above.

In the embodiment shown herein, an impact pressure distribution is realized by varying the nozzle configuration for a plurality of nozzles, but alternative approaches may be utilized to provide similar effects. A plurality of tubes arranged for supplying water to nozzles may be provided with respective valves, and a water jet may be controlled by manipulating the valves. A pressure source such as a pump, etc., may be provided for respective nozzles to thereby vary water jets. Such arrangements also fall within the scope of the present invention.

Other embodiments will be described with reference to FIGS. 6a and 6b. FIG. 6a is an elevation view showing the turntable and the fluid jet nozzle for the dressing operation in the polishing apparatus according to the present invention. In this embodiment, a single nozzle 31 is provided, but the fluid jet may cover the entire area of the polishing cloth 23, because the nozzle supporting member 34 travels over the polishing cloth 23 in an oscillating manner during a dressing operation, as shown by an arrow in FIG. 6b. Besides, even though only a single fluid jet is provided, it is possible to vary time expended on dressing to influence respective portions of the polishing cloth 23, thereby ensuring an effect similar to that provided in such a case where a plurality of nozzles is employed, as described above, by suitably determining a pattern of travel of the nozzle supporting member 34, and the rotation speed of the turntable.

In the above-described embodiment, although a water jet is used, the present invention may also be applied to a dressing operation in which a liquid other than water and a gas are used as a jet to dress the object.

In the above-described embodiment, although polishing apparatus and method for polishing a semiconductor wafer into a flat and mirror-like configuration are described, the object to be polished is not limited to a semiconductor wafer.

Moreover, in the above-described embodiment, although the present invention has been described with reference to an embodiment in which a single semiconductor wafer is polished with a single top ring, it is also possible to provide an alternative embodiment in which a template-like top ring is formed with a plurality of water ports so that a plurality of wafers may be polished in a similar manner.

The present invention is also applicable to a case in which a fluid jet is used to dress a polishing cloth for use in a polishing apparatus whereby an object is polished by means of a roller around which a polishing cloth is wound.

(Effect of the Invention)

As above-described, in accordance with the present invention, a dressing operation may be carried out on a polishing cloth which does not have an even configuration when a fluid jet such as a water jet, etc., is applied against the polishing cloth to dress the cloth. Therefore, an entire surface of the polishing cloth can be dressed in an even manner, thereby improving its operating efficiency.

We claim:

1. An apparatus for polishing an object by urging a surface of the object against a surface of a polishing cloth while causing relative movement therebetween and supplying a polishing liquid therebetween, said polishing apparatus including a dressing apparatus for dressing said polishing cloth to renew said polishing cloth for continued polishing, said dressing apparatus comprising:

a plurality of nozzles for spraying respective fluid jets against said surface of said polishing cloth, said nozzles having respective axes located at different distances from a rotational axis of said polishing cloths; and

means for varying impact pressure imparted by said fluid jets to said surface of said polishing cloth over different areas thereof.

2. An apparatus as claimed in claim 1, wherein said means comprises means for providing that a flow velocity of said fluid jet from at least one said nozzle is different than a flow velocity of said fluid jet from at least one other said nozzle.

3. An apparatus as claimed in claim 2, wherein flow velocities of said fluid jets from all of said nozzles are different.

4. An apparatus as claimed in claim 1, wherein said means comprises means for providing that a flow rate of said fluid jet from at least one said nozzle is different than a flow rate of at least one other said nozzle.

5. An apparatus as claimed in claim 4, wherein flow rates of said fluid jets of all of said nozzles are different.

6. An apparatus as claimed in claim 1, wherein said means comprises means for providing that an angle of spray of said fluid jet from at least one said nozzle is different than an angle of spray of said fluid jet from at least one other said nozzle.

7. An apparatus as claimed in claim 6, wherein angles of spray of said fluid jets of all of said nozzles are different.

8. An apparatus as claimed in claim 1, wherein said means comprises at least one said nozzle having a cross-sectional configuration different from a cross-sectional configuration of at least one other said nozzle.

9. An apparatus as claimed in claim 8, wherein all of said nozzles have different cross-sectional configurations.

10. An apparatus as claimed in claim 1, wherein said means comprises means for providing that a cross-sectional configuration of said fluid jet from at least one said nozzle is different than a cross-sectional configuration of said fluid jet from at least one other said nozzle.

11. An apparatus as claimed in claim 10, wherein cross-sectional configurations of all of said fluid jets are different.

12. An apparatus as claimed in claim 1, wherein said nozzles are connected to respective fluid supply sources that provide at least one of different supply pressure and different flow rate.

13. An apparatus as claimed in claim 1, wherein each said nozzle has connected thereto a respective fluid supply line, and each said fluid supply line has a valve or orifice to control selectively the supply of fluid to the respective said nozzle.

14. An apparatus as claimed in claim 1, further comprising means to blend cavitation bubbles into at least one said fluid jet.

15. An apparatus as claimed in claim 1, further comprising a cover covering said nozzles and polishing cloth to prevent splashing of fluid from said fluid jets.

16. A dressing apparatus for dressing a polishing cloth to be employed in a polishing apparatus used for polishing an object by urging a surface of the object against a surface of the polishing cloth while causing relative movement therebetween and supplying a polishing liquid therebetween, said dressing apparatus comprising:

a plurality of nozzles for spraying respective fluid jets against the surface of the polishing cloth, said nozzles having respective axes to be located at different distances from a rotational axis of the polishing cloth; and

means for varying impact pressure to be imparted by said fluid jets to the surface of the polishing cloth over different areas thereof.

17. An apparatus as claimed in claim 16, wherein said means comprises means for providing that a flow velocity of

said fluid jet from at least one said nozzle is different than a flow velocity of said fluid jet from at least one other said nozzle.

18. An apparatus as claimed in claim 17, wherein flow velocities of said fluid jets from all of said nozzles are different.

19. An apparatus as claimed in claim 16, wherein said means comprises means for providing that a flow rate of said fluid jet from at least one said nozzle is different than a flow rate of at least one other said nozzle.

20. An apparatus as claimed in claim 19, wherein flow rates of said fluid jets of all of said nozzles are different.

21. An apparatus as claimed in claim 16, wherein said means comprises means for providing that an angle of spray of said fluid jet from at least one said nozzle is different than an angle of spray of said fluid jet from at least one other said nozzle.

22. An apparatus as claimed in claim 21, wherein angles of spray of said fluid jets of all of said nozzles are different.

23. An apparatus as claimed in claim 16, wherein said means comprises at least one said nozzle having a cross-sectional configuration different from a cross-sectional configuration of at least one other said nozzle.

24. An apparatus as claimed in claim 23, wherein all of said nozzles have different cross-sectional configurations.

25. An apparatus as claimed in claim 16, wherein said means comprises means for providing that a cross-sectional configuration of said fluid jet from at least one said nozzle is different than a cross-sectional configuration of said fluid jet from at least one other said nozzle.

26. An apparatus as claimed in claim 25, wherein cross-sectional configurations of all of said fluid jets are different.

27. An apparatus as claimed in claim 16, wherein said nozzles are connected to respective fluid supply sources that provide at least one of different supply pressure and different flow rate.

28. An apparatus as claimed in claim 16, wherein each said nozzle has connected thereto a respective fluid supply line, and each said fluid supply line has a valve or orifice to control selectively the supply of fluid to the respective said nozzle.

29. An apparatus as claimed in claim 16, further comprising means to blend cavitation bubbles into at least one said fluid jet.

30. A method of dressing a polishing cloth employed in a polishing operation wherein a surface of an object is polished by urging said surface against a surface of the polishing cloth while causing relative rotation therebetween and supplying a polishing liquid therebetween, said method comprising:

spraying fluid jets against said surface of said polishing cloth from a plurality of respective nozzles having respective axes located at different distances from a rotational axis of said polishing cloth; and

varying impact pressure imparted by said fluid jets to said surface of said polishing cloth over different areas thereof.

31. A method as claimed in claim 30, wherein said varying comprises providing that a flow velocity of said fluid jet from at least one said nozzle is different than a flow velocity of said fluid jet from at least one other said nozzle.

32. A method as claimed in claim 31, wherein flow velocities of said fluid jets from all of said nozzles are different.

33. A method as claimed in claim 30, wherein said varying comprises providing that a flow rate of said fluid jet from at least one said nozzle is different than a flow rate of at least one other said nozzle.

34. A method as claimed in claim 33, wherein flow rates of said fluid jets of all of said nozzles are different.

35. A method as claimed in claim 30, wherein said varying comprises providing that an angle of spray of said fluid jet from at least one said nozzle is different than an angle of spray of said fluid jet from at least one other said nozzle.

36. A method as claimed in claim 35, wherein angles of spray of said fluid jets of all of said nozzles are different.

37. A method as claimed in claim 30, wherein said varying comprises providing that at least one said nozzle has a cross-sectional configuration different from a cross-sectional configuration of at least one other said nozzle.

38. A method as claimed in claim 37, wherein all of said nozzles have different cross-sectional configurations.

39. A method as claimed in claim 30, wherein said varying comprises providing that a cross-sectional configuration of said fluid jet from at least one said nozzle is different than a cross-sectional configuration of said fluid jet from at least one other said nozzle.

40. An apparatus as claimed in claim 39, wherein cross-sectional configurations of all of said fluid jets are different.

41. A method as claimed in claim 30, comprising connecting said nozzles to respective fluid supply sources that provide at least one of different supply pressure and different flow rate.

42. A method as claimed in claim 30, comprising connecting each said nozzle to a respective fluid supply line having a valve or orifice to control selectively the supply of fluid to the respective said nozzle.

43. A method as claimed in claim 30, further comprising blending cavitation bubbles into at least one said fluid jet.

44. A method as claimed in claim 30, further comprising covering said nozzles and polishing cloth to prevent splashing of fluid from said fluid jets.

45. A method as claimed in claim 30, wherein said fluid jets comprise water jets.

46. An apparatus for polishing an object by urging a surface of the object against a surface of a polishing cloth while causing relative movement therebetween and supplying a polishing liquid therebetween, said polishing apparatus including a dressing apparatus for dressing said polishing cloth to renew said polishing cloth for continued polishing, said dressing apparatus comprising:

at least one nozzle for spraying a fluid jet against said surface of said polishing cloth; and

means for moving said nozzle over said surface of said polishing cloth and for varying the time that said fluid jet impacts onto different areas thereof.

47. An apparatus as claimed in claim 46, further comprising means to blend cavitation bubbles into said fluid jet.

48. An apparatus as claimed in claim 46, further comprising a cover covering said nozzle and said polishing cloth to prevent splashing of fluid from said fluid jet.

49. An apparatus as claimed in claim 46, wherein said polishing cloth is mounted on a rotatable turntable, and further comprising means for varying the speed of rotation of said turntable during movement of said nozzle over said surface of said polishing cloth.

50. An apparatus as claimed in claim 46, wherein said nozzle is supported by a nozzle support member, and said means comprises means for moving said nozzle support member over the polishing cloth.

51. A dressing apparatus for dressing a polishing cloth to be employed in a polishing apparatus used for polishing an object by urging a surface of the object against a surface of the polishing cloth while causing relative movement therebetween and supplying a polishing liquid therebetween, said dressing apparatus comprising:

at least one nozzle for spraying a fluid jet against the surface of the polishing cloth; and

means for moving said nozzle over the surface of the polishing cloth and for varying the time that said fluid jet impacts onto different areas thereof.

52. An apparatus as claimed in claim 51, further comprising means to blend cavitation bubbles into said fluid jet.

53. An apparatus as claimed in claim 51, wherein said nozzle is supported by a nozzle support member, and said means comprises means for moving said nozzle support member over the polishing cloth.

54. A method of dressing a polishing cloth employed in a polishing operation wherein a surface of an object is polished by urging said surface against a surface of the polishing cloth while causing relative rotation therebetween and supplying a polishing liquid therebetween, said method comprising:

spraying a fluid jet from a nozzle against said surface of said polishing cloth; and

moving said nozzle over said surface of said polishing cloth and varying the time that said fluid jet impacts onto different areas thereof.

55. A method as claimed in claim 54, further comprising blending cavitation bubbles into said fluid jet.

56. A method as claimed in claim 54, further comprising covering said nozzle and said polishing cloth to prevent splashing of fluid from said fluid jet.

57. A method as claimed in claim 54, wherein said fluid jet comprises a water jet.

58. A method as claimed in claim 54, wherein said polishing cloth is mounted on a rotatable turntable, and further comprising varying the speed of rotation of said turntable during movement of said nozzle over said surface of said polishing cloth.

59. A method as claimed in claim 54, wherein said nozzle is supported by a nozzle support member, and said moving comprises moving said nozzle support member over said polishing cloth.

* * * * *

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Huey

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(45) Date of Patent: Sep. 4, 2001

(54) **CLEANING AND SLURRY DISTRIBUTION SYSTEM ASSEMBLY FOR USE IN CHEMICAL MECHANICAL POLISHING APPARATUS**

(75) Inventor: **Sidney Huey**, Oakland, CA (US)

(73) Assignee: **Applied Materials, Inc.**, Santa Clara, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

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(51) **Int. Cl.**[7] **B24B 29/00**

(52) **U.S. Cl.** **451/288**; 451/56

(58) **Field of Search** 451/56, 444, 443, 451/446, 288, 60

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Primary Examiner—Joseph J. Hail, III
Assistant Examiner—David B. Thomas
(74) *Attorney, Agent, or Firm*—Fish & Richardson

(57) **ABSTRACT**

A cleaning and slurry distribution assembly for use in a chemical mechanical polishing apparatus. The cleaning assembly includes a plurality of nozzles for directing a cleaning fluid against a polishing pad. The cleaning assembly further includes a housing for containing residual droplets, slurry and contaminants. The slurry distribution assembly includes a ring for optimally distributing slurry on the polishing pad.

18 Claims, 5 Drawing Sheets

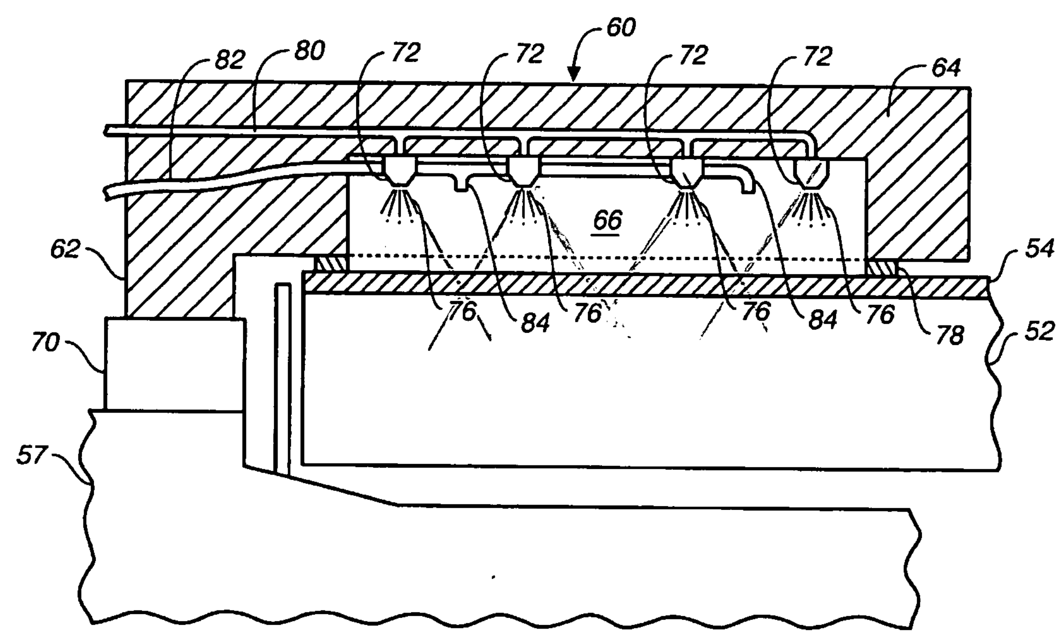
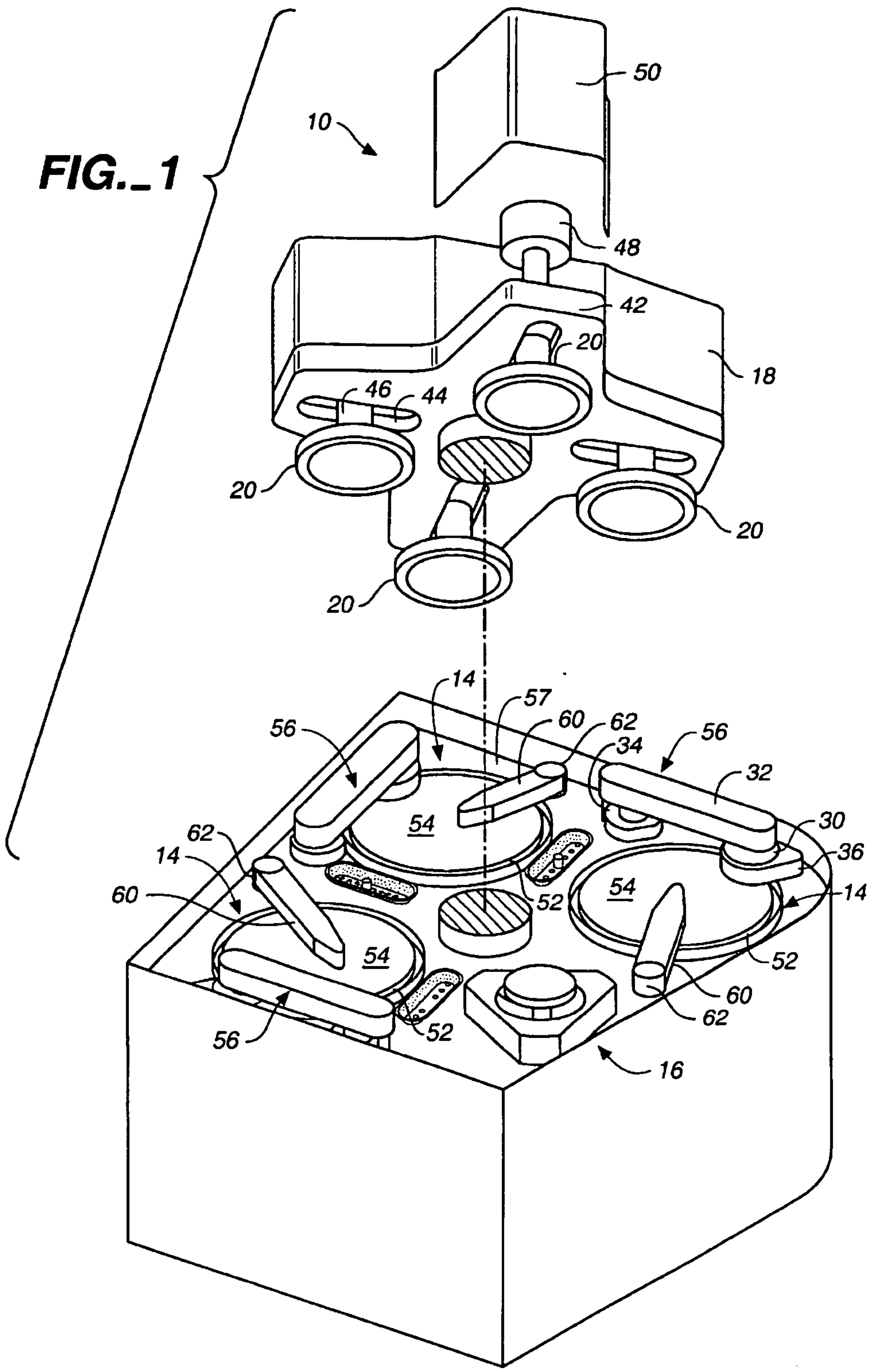


FIG._1



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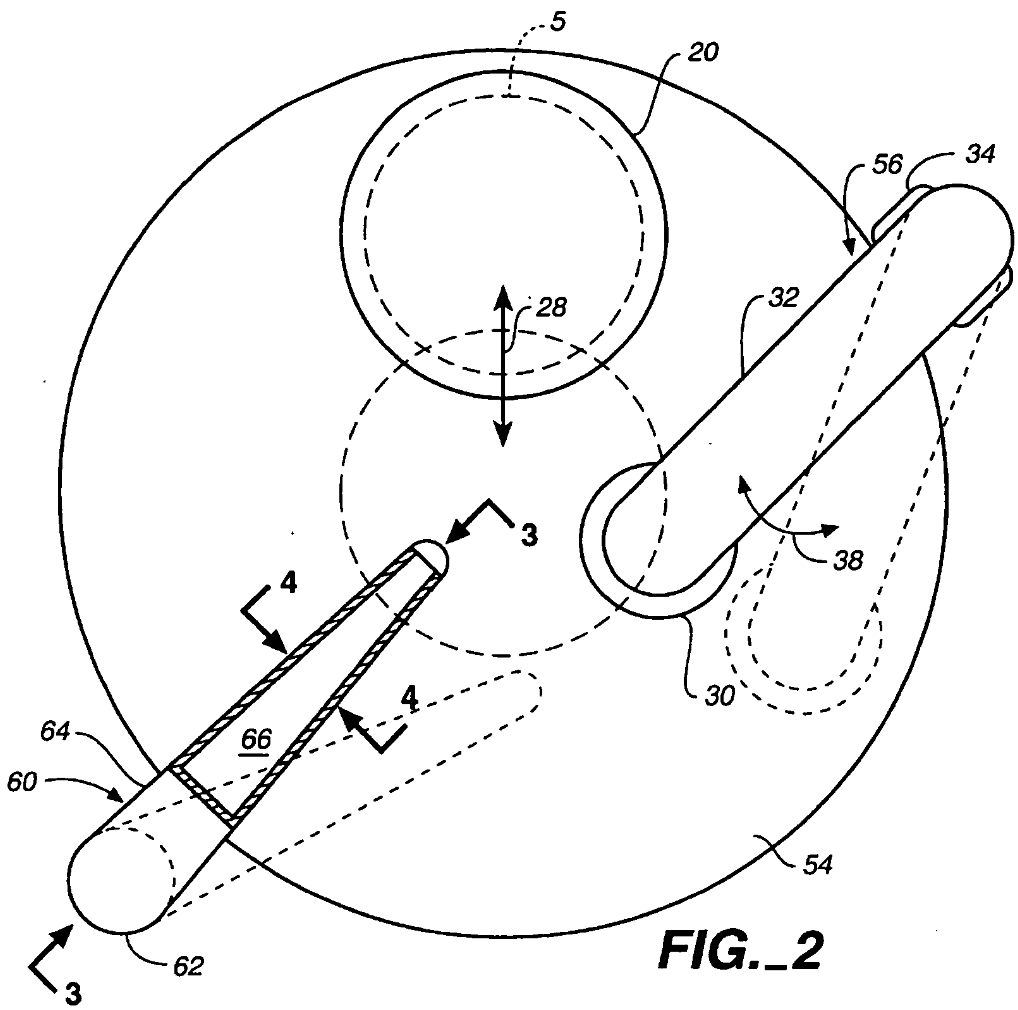

FIG._2

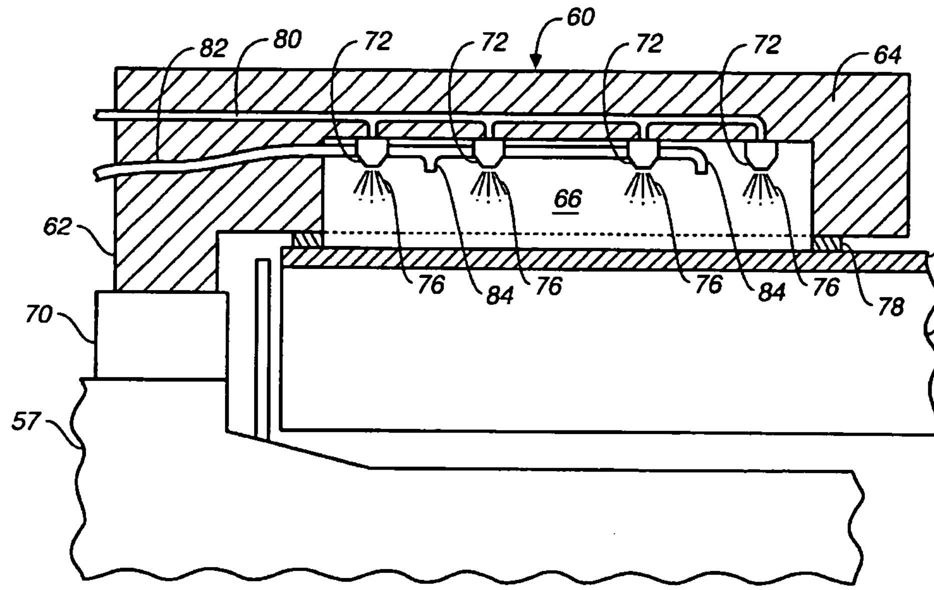
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FIG._3

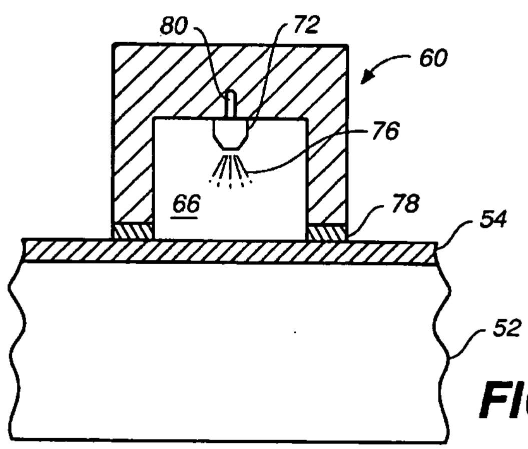
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FIG._4

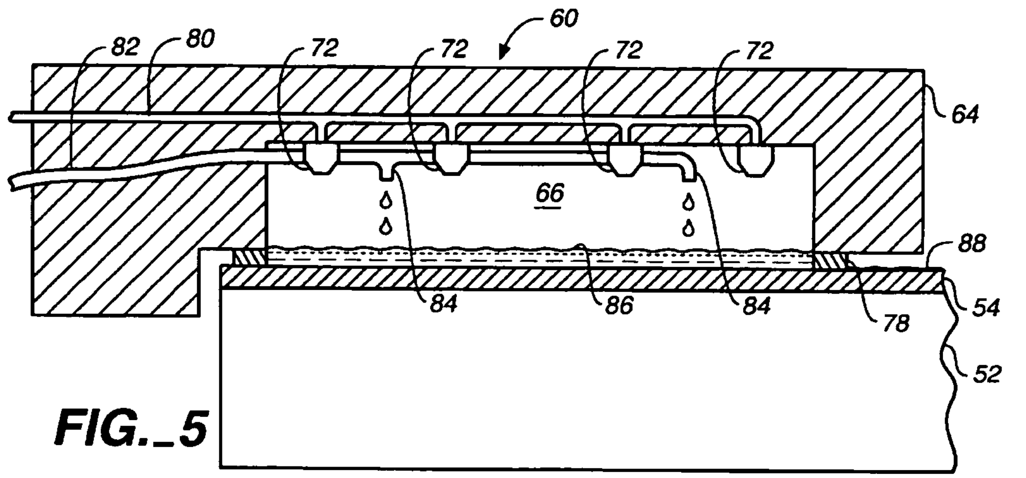
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FIG._5

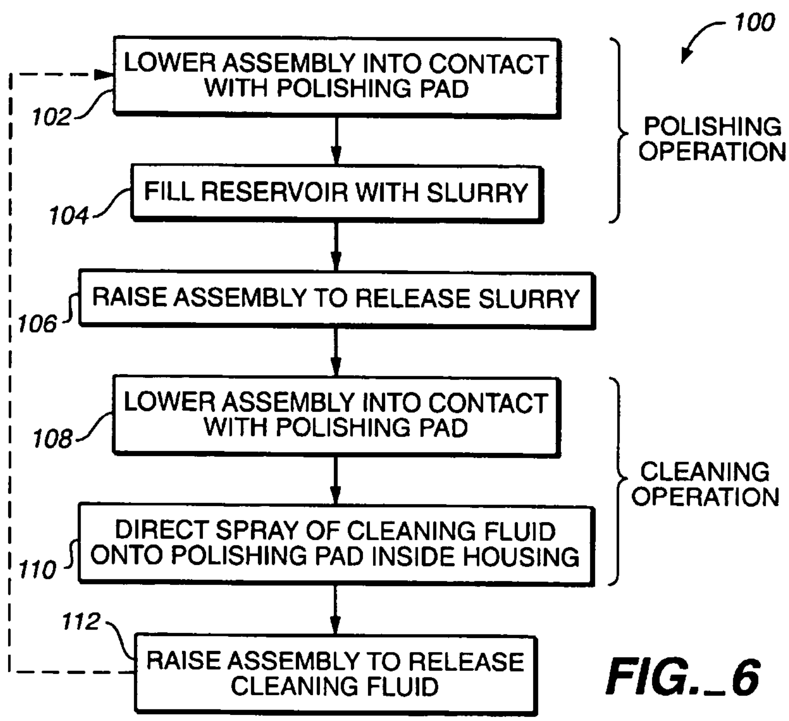
100
LOWER ASSEMBLY INTO CONTACT WITH POLISHING PAD
102
FILL RESERVOIR WITH SLURRY
104
POLISHING OPERATION
RAISE ASSEMBLY TO RELEASE SLURRY
106
LOWER ASSEMBLY INTO CONTACT WITH POLISHING PAD
108
DIRECT SPRAY OF CLEANING FLUID ONTO POLISHING PAD INSIDE HOUSING
110
CLEANING OPERATION
112
RAISE ASSEMBLY TO RELEASE CLEANING FLUID

FIG._6

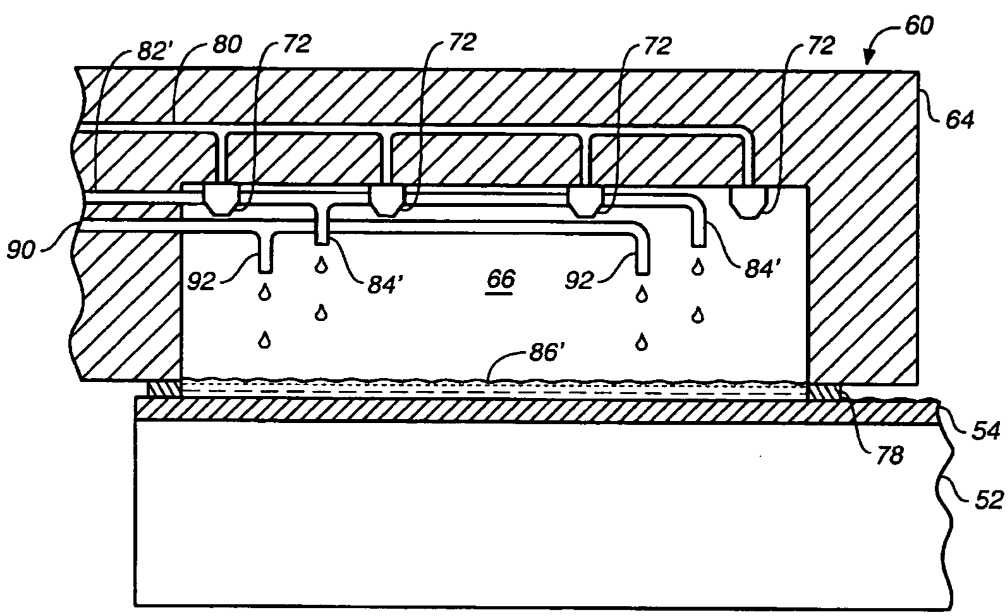

FIG._7

CLEANING AND SLURRY DISTRIBUTION SYSTEM ASSEMBLY FOR USE IN CHEMICAL MECHANICAL POLISHING APPARATUS

BACKGROUND

The invention relates chemical mechanical polishing of substrates, and more particularly to dispensing slurry onto a polishing pad and cleaning the polishing pad.

Chemical mechanical polishing (CMP) is a process by which a substrate surface is planarized to a uniform level. In a conventional CMP apparatus, substrate is mounted on a rotatable carrier head and pressed against a rotating polishing pad. An abrasive chemical solution (slurry) is applied onto the polishing pad to aid in the polishing of the substrate to achieve a desired surface finish. Over time, the polishing process glazes the polishing pad and creates irregularities in the polishing pad surface that can adversely affect the substrate surface finish. The polishing pad surface is typically "conditioned" by scouring the polishing pad surface with an abrasive device known as a conditioning disk to deglaze and roughen the polishing pad surface. Periodically conditioning the pad maintains the pad surface at a consistent state of roughness to achieve consistent polishing uniformity.

One problem encountered in CMP is the generation of contaminants on the polishing pad surface during the polishing and conditioning procedures. These contaminants have a material adverse affect on the polishing process. For example, contaminants include (but are not limited to) abraded polishing pad material, dried slurry particles, conditioning disk material and airborne contaminants. Adverse material effects include (but are not limited to) scratching of the substrate and embedding of the particles in the polishing pad or substrate. It would be advantageous if the polishing apparatus cleaned the polishing pad to provide a substantially contaminant-free polishing pad.

Another problem in CMP is that slurry is an expensive consumable. A CMP system may use more than two hundred milliliters of slurry per minute. In general, the substrate takes two to three minutes to polish. Thus, a CMP system can use up to a sixth of a gallon of slurry per substrate. The per substrate cost of CMP could be reduced considerably by reducing the amount of slurry used. In addition, where excessive slurry is applied, the substrate can hydroplane over the surface of the polishing pad, thereby reducing the polishing rate. It would be advantageous if the CMP apparatus that reduced slurry consumption in the polishing process.

SUMMARY

In one aspect, the invention is directed to an apparatus for use in a chemical mechanical polishing system. The apparatus has a housing positionable over a polishing pad and at least one nozzle covered by the housing to spray a cleaning fluid against the polishing pad.

Implementations of the invention may include the following. The cleaning fluid may be deionized water, and may be sprayed by the nozzle under hydraulic pressure. The housing may extends toward the center of the polishing pad, and may be configured to be raised and lowered over a region of the polishing pad. A retainer may be joined to a lower surface of the housing, and may contact a surface of the polishing pad, e.g., at a pressure less than about 5 psi. A first feed line may supply the cleaning fluid to the assembly, a second feed line may supply a solution of deionized water and an agent selected from the group consisting of a corrosion inhibitor, a cleaner, an oxidizer, a pH adjustor, a dilution fluid, and a surface wetting agent, and a third feed line may supply an abrasive solution.

In another aspect, the invention is directed to a method of cleaning the surface of a polishing pad in a chemical mechanical polishing system. A cleaning fluid is directed from a cleaning assembly against a polishing pad that has residual contaminants, and the cleaning fluid is substantially contained within a housing of the cleaning assembly.

Implementations of the invention may include the following features. The cleaning fluid may be deionized water, and droplets of the cleaning fluid may be produced by subjecting the deionized water to a hydraulic pressure, e.g., of less than about 60 psi, such as less than about 10 psi.

In another aspect, the invention is directed to an apparatus for distributing slurry onto a polishing surface. The apparatus has a retainer having a lower surface in close proximity to the polishing surface and enclosing a region, and an outlet to distribute slurry to the enclosed region to form a reservoir of slurry in the enclosed region. The slurry is distributed to a region not enclosed by the retainer by traveling between the polishing surface and the lower surface of the retainer.

In another aspect, the invention is directed to a method of preparing the surface of a polishing pad in a chemical mechanical polishing system for polishing a substrate. In the method, a cleaning fluid impinges against the polishing pad having at least one of residual polishing slurry, contaminants and fluid. the cleaning fluid, residual polishing slurry, contaminants and fluid are substantially contained by means of a housing. The housing is lifted to expel at least a portion of the residual polishing slurry, contaminants and fluid from the polishing pad. A polishing slurry is applied to the polishing pad, and the polishing slurry is spread over the polishing pad with a lower surface of the housing.

The present invention advantageously cleans the polishing pad to provide a substantially contaminant-free polishing pad. The invention also can apply a uniform layer of polishing slurry to the polishing pad to provide improved polishing and planarization of the substrate while minimizing/optimizing the amount of slurry used.

Other features and advantages will become apparent from the following description, including the drawings and the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic exploded view of a chemical mechanical polishing system.

FIG. 2 is a schematic top view of the CMP system of FIG. 1 showing a carrier head, a conditioning apparatus, and a cleaning and slurry distribution arm assembly.

FIG. 3 is a cross-sectional view of the cleaning and slurry distribution assembly of FIG. 2 taken along line 3—3.

FIG. 4 is a cross-sectional view of the cleaning and slurry distribution assembly of FIG. 2 taken along line 4—4.

FIG. 5 is a cross-sectional view of the cleaning and slurry distribution assembly being used to distribute slurry on the polishing pad.

FIG. 6 is a flow chart showing the process performed with the cleaning and slurry distribution assembly.

FIG. 7 is a cross-sectional view of a cleaning and slurry distribution assembly that includes multiple slurry delivery lines.

DETAILED DESCRIPTION

Referring to FIG. 1, a chemical mechanical polishing apparatus 10 includes three independently-operated polish-

ing stations 14, a substrate transfer station 16, and a rotatable carousel 18 which choreographs the operation of four independently rotatable carrier heads 20. A similar polishing apparatus is discussed in U.S. Pat. No. 5,738,574, the entirety of which is incorporated herein by reference.

The carousel 18 has a support plate 42 with slots 44 through which drive shafts 46 for the carrier heads 20 extend. The carrier heads 20 independently rotate and oscillate back-and-forth in the slots 44. The carrier heads 20 are rotated by the respective motors 48, which are normally hidden behind removable sidewalls 50 of the carousel 18. In operation, a substrate is transferred from the transfer station 16 to a carrier head 20. The carousel 18 then transfers the carrier head and substrate through a series of one or more polishing stations 14, and finally returns the substrate to the transfer station 16.

Each polishing station 14 includes a rotatable platen 52 having secured thereto a polishing pad 54. The polishing station 14 optionally includes a pad conditioner 56 mounted to a tabletop 57 of the polishing apparatus 10. Each pad conditioner 56 includes a conditioner head 30, an arm 32, and a base 34 for positioning the conditioner head 30 over the surface of the polishing pad to be conditioned. Each polishing station 14 also includes a cup 36 containing a fluid for rinsing the conditioner head 30.

Referring to FIG. 2, the polishing pad 54 is conditioned by the pad conditioner 56 while the polishing pad 54 polishes a substrate 5 (shown in phantom) mounted on the carrier head 20. The conditioner head 30 sweeps across the polishing pad 54 with a motion that is synchronized with the motion of the carrier head 20 to avoid collision. Such synchronization may be controlled, for example, by a general purpose computer. For example, the carrier head 20 may be positioned in the center of the polishing pad 54 and the conditioner head 30 may be immersed in a rinsing fluid contained within the cup 36. During polishing, the cup 36 may pivot out of the way, and the carrier head 20 and the conditioner head 30 may be swept back-and-forth across the polishing pad 54 (e.g., between the positions shown in solid and phantom) as shown by arrows 28 and 38, respectively.

Each polishing station 14 also includes a corresponding slurry delivery and cleaning arm assembly 60 mounted to the table top 57 by a support post 62. The arm assembly 60 serves two main purposes: to spread slurry over the surface of the pad in a thin layer, and to remove residues and contaminants, such as residual slurry, dirt, dust, abraded substrate material, abraded polishing pad material and other contaminants that would have a material adverse affect on the polishing process, from the polishing pad surface. The arm assembly 60 extends over the polishing pad from the pad edge to the pad center. The arm assembly 60 may be designed and configured to pivot about the support post 62 so as to sweep across over the surface of the polishing pad 54. Specifically, the motion of the arm assembly 60 may be synchronized with the motion of the carrier head 20 and the conditioner head 30 to avoid collisions therebetween. Alternately, if the carrier head does not move over the pad center, the arm assembly 60 can remain stationary during polishing.

As shown in FIGS. 2, 3 and 4, the slurry dispensing/cleaning arm assembly 60 includes an elongated housing 64 that extends from the platen edge to near the platen center. The housing 64 is supported by the support post 62, and has a recess with an opening on the side of the housing that faces the polishing pad 54. The volume between the polishing pad 54 and the housing 64 defines a chamber 66. The chamber 66 contains the streams of cleaning fluid, and serves as a container for the slurry.

To clean the polishing pad, a spray of cleaning fluid is directed from the arm assembly 60 onto the polishing pad surface. Specifically, a set of fluid dispensing nozzles 72 are located inside the chamber 66 to spray streams 76 of a cleaning fluid, such as deionized water, against the top surface of the polishing pad 54. Although four nozzles are illustrated, the assembly 60 could include more or fewer nozzles. The assembly may include 4–6 nozzles. The stream 76 from each nozzle 72 cleans and loosens residues and contaminants (such as residual liquid slurry, dust, dried slurry, abraded polishing pad material, abraded substrate, etc.) from the polishing pad 54, particularly from any grooves or holes in the polishing pad 54. Such cleaning advantageously prepares the polishing pad 54 for polishing. The cleaning fluid is supplied to the nozzles by a feed line 80. Although illustrated as a passage through the housing 64, the feed line 80 could be implemented as tubing inside or outside the chamber 66.

The nozzles 72 may be any conventional nozzle capable of atomizing the cleaning fluid. For example, each nozzle may be an airless nozzle in which the cleaning fluid is forced through a small orifice under hydraulic pressure, such as less than about 60 psi, e.g., about 10–60 psi. The nozzles may also be air-assisted nozzles in which the cleaning fluid is forced through a small orifice under pressure (such as 60 psi) and the resultant fluid stream is further atomized and propelled by a compressed gas, such as compressed air. The compressed air may be pressurized, e.g., up to 10 psi, or about 5 psi. As such, the cleaning liquid may be sprayed at a rate in the range of about 0.2 to 1.0 gal/min. The nozzles 72 may be constructed from a chemical and corrosion resistant material, such as a polyvinyldene fluoride (PVDF) thermoplastic. For example, each nozzle may be a KYNAR4® Series Spray Nozzle, Model HVV-KY.

The assembly also includes a lower retainer 78 that projects downwardly from the housing 64, and can be lowered to contact the polishing pad 54. The housing 64 and the retainer 78 may be a unitary body, or the retainer 78 may be secured (e.g., by an adhesive or by screws or bolts) to the housing 64. When the lower retainer 78 contacts the polishing pad 54, it forms a dam to retain slurry and rinse water within a reservoir formed by the retainer and pad. The lower retainer 78 may contact the pad 54 at pressure of about 1 psi. The retainer 78 and the housing 64 may be constructed from a chemically resistant and wear resistant material, such as a polyphenylsulfide (PPS), a polytetrafluoroethylene (PTFE) or DELRIN™.

The arm assembly 60 is adapted to move up and down (i.e., to be raised and lowered with respect to the polishing pad 54) by a pneumatic or mechanical actuator 70. The arm assembly 60 is lowered in contact with the polishing pad 54 to enclose the streams 76 of deionized water and prevent the resulting waste materials (e.g., polishing slurry, residues, contaminants, waste water, etc.) from splashing and collecting on the landing on exterior surfaces of the polishing apparatus 10. These materials might otherwise form dried deposits which can flake off and land on the polishing pad 54 causing a defect in the substrate. The splashed liquids may also penetrate the interior workings of the polishing apparatus 10, causing corrosion and other damage. When cleaning is completed, the arm assembly 60 may be raised to allow the contained liquid and residual materials to be centrifugally expelled from the polishing pad 54 as the pad rotates. Expelling the water, diluted slurry, residues and contaminants from the arm assembly 60 prevents the substrate from being polished with diluted slurry.

The arm assembly 60 is also be used to distribute a polishing slurry to the polishing pad 54. A slurry delivery line 82 may connect one or more slurry outlets 84 to a slurry source for the polishing slurry. As shown in FIG. 5, after the pad has been cleaned, assembly 60 is lowered so that the retainer 78 contacts the polishing pad 54. Then the polishing slurry is fed from the slurry delivery line 82 through the slurry outlets 84 so that it accumulates in a reservoir 86 contained by the retainer 78 and the housing 64. The polishing slurry in the reservoir then either seeps out between a thin gap between the retainer 78 and the polishing pad 54, or is carried beneath the lower retainer 78 by grooves or perforations in the polishing pad 54. In either case, this arm assembly 60 leaves a thin layer of slurry 88 on the polishing pad 54. The assembly housing 64 also prevents the polishing slurry from splattering and coating the exterior surfaces or penetrating the interior surfaces of the polishing apparatus 10.

Referring to FIG. 6, a method 100 performed with the arm assembly 60 begins with a polishing operation when the assembly 60 is lowered into contact with the polishing pad 54 (step 102). The polishing slurry is directed through the slurry delivery line 82 to create the reservoir 86 of slurry on the polishing pad inside the housing 64 (step 104). The polishing proceeds for a period of time, such as about 15 seconds to 2 minutes, during which the reservoir 86 can be periodically or intermittently refilled. Specifically, slurry can be supplied at a flow rate equal to or slightly greater than the consumption rate of the slurry for a given set of polishing parameters. For example, slurry may be dispensed through the slurry outlets 84 at a flow rate in the range of about 50 to 200 ml/min. A well-distributed and uniform thin layer of slurry is deposited the pad 54 by the wiping action of the retainer 78. By depositing a thin layer of slurry, excessive slurry usage can be greatly reduced.

After polishing has been completed, the arm assembly 60 is lifted and the remaining slurry is centrifugally expelled (step 106). During the cleaning operation, the arm assembly 60 is lowered back into contact with the polishing pad (step 108). Then the cleaning fluid (e.g., deionized water) is forced through the nozzles to direct a spray of cleaning fluid onto the polishing pad 54 inside the housing 64 (step 110). The cleaning fluid may be sprayed at a rate of about 0.5 gal./min. The arm assembly 60 may be held in a horizontal position, or it may be swept horizontally across a portion of the polishing pad 54 adjacent the region conditioned by the conditioner head 32. In the later application, the assembly 60 may pivot over a fixed area above the polishing pad 54. If the fixed area does not overlap the area swept by the conditioner arm 32 and head 30, there is no need for a process controller to control the movements of the assembly 60, the carrier head 20, and the pad conditioner 56. The cleaning mode is run for a period of time sufficient to suitably clean the pad in preparation for polishing a substrate, e.g., ten seconds. Once the cleaning operation is completed, the arm assembly 60 is lifted away from the polishing pad so that the waste water inside the housing 64 can be centrifugally expelled from the rotating polishing pad 54 (step 112). It is important for such fluids and materials to be removed from the pad to ensure that the pad is free of contaminants prior to polishing a substrate.

FIG. 7 shows another embodiment of the slurry delivery/rinse arm assembly that includes dual slurry delivery lines. The first slurry delivery line 82' delivers a first slurry component to the polishing pad 54 via one or more of the slurry outlets 84'. A second slurry delivery line 90 delivers a second slurry component to the polishing pad via one or

more outlets 92. The first and second slurry components are mixed together in the reservoir formed by the retainer 78. Both slurry delivery lines could deliver abrasive solutions. Alternately, the second slurry delivery line could be used to supply a chemical to control the polishing process, such as a corrosion inhibitor, an oxidizer, a dilution fluid, a pH adjustor, or a surface wetting agent.

For example, in CMP applications to polish a tungsten film layer, the first slurry component may include a solution of ferric nitrate and additives, such as buffers. The second slurry component may include an abrasive solution, such as fumed or colloidal silica, or alumina. Chemical reactions take place between constituents of the first and second slurry components that may age the resultant mixture. Thus, the first and second slurry components are mixed just prior to being utilized as a polishing medium to polish the tungsten.

The lower surface of retainer 78 can be roughened, or an abrasive material can be coated on the lower surface of the retainer 78. When the arm assembly 60 is lowered into contact with the polishing pad 54, the abrasive lower surface of the retainer 78 roughens and deglazes the polishing pad. Thus, the arm assembly 60 can be used to condition the polishing pad. In this implementation, the polishing apparatus 10 need not include a separate pad conditioner 56.

The invention has been described with reference to various drawings, aspects and preferred embodiments. It is to be understood that the above descriptions are made by way of illustration, and that the invention may take other forms within the spirit of the structures and methods described herein. The invention includes variations and modifications thereof as defined in the claims attached hereto.

What is claimed is:

1. An apparatus for use in a chemical mechanical polishing system, comprising:

a housing positionable over a polishing surface and movable in a direction normal to the polishing surface, wherein a part of the housing that covers the nozzle contacts the polishing surface to enclose the polishing surface beneath the nozzle; and

at least one nozzle covered by the housing to spray a cleaning fluid against the polishing surface.

2. The apparatus of claim 1, wherein the cleaning fluid is deionized water.

3. The apparatus of claim 1, wherein the housing is configured to be raised and lowered over a region of the polishing surface.

4. The apparatus of claim 1, wherein the at least one nozzle is adapted to spray the cleaning fluid under hydraulic pressure.

5. The apparatus of claim 1, wherein the housing extends toward the center of the polishing surface.

6. The apparatus of claim 1, further comprising a retainer joined to a lower surface of the housing.

7. An apparatus for use in a chemical mechanical polishing system, comprising:

a housing positionable over a polishing surface;

at least one nozzle covered by the housing to spray a cleaning fluid against the polishing surface; and

a retainer joined to a lower surface of the housing, wherein the retainer contacts a surface of the polishing surface.

8. The apparatus of claim 7 wherein the retainer contacts the polishing surface at a pressure less than about 5 psi.

9. The apparatus of claim 1, further including a first feed line to supply the cleaning fluid to the assembly.

10. The apparatus of claim 9, wherein the assembly further including a second feed line to supply an aqueous

solution of deionized water and an agent selected from the group consisting of a corrosion inhibitor, an oxidize, a cleaner, a pH adjustor, a dilution fluid, and a surface wetting agent.

11. An apparatus for use in a chemical mechanical polishing system, comprising:

a housing assembly positionable over a polishing surface, wherein the assembly includes a first feed line to supply a cleaning fluid, a second feed line to supply an aqueous solution of deionized water and an agent selected from the group consisting of a corrosion inhibitor, an oxidize, a cleaner, a pH adjustor, a dilution fluid, and a surface wetting agent, and a third feed line to supply an abrasive solution; and

at least one nozzle covered by the housing to spray the cleaning fluid against the polishing surface.

12. The apparatus of claim 1, wherein the housing is arranged to substantially contain the cleaning fluid, residual polishing slurry, contaminants and fluid, and wherein a lower surface of the housing spreads the polishing slurry over the polishing surface.

13. The apparatus of claim 1, wherein the housing further comprises:

a retainer having a lower surface in close proximity to the polishing surface and enclosing a region; and

an outlet to distribute slurry to the enclosed region to form a reservoir of slurry in the enclosed region, wherein the slurry is distributed to a region not enclosed by the retainer by traveling between the polishing surface and the lower surface of the retainer.

14. The apparatus of claim 1, wherein the cleaning fluid is centrifugally removed from the polishing surface.

15. A method of cleaning the surface of a polishing pad in a chemical mechanical polishing system, comprising:

lowering a housing of a cleaning assembly into close proximity of a polishing surface;

directing a cleaning fluid from the cleaning assembly against the polishing surface that has residual contaminants;

substantially containing the cleaning fluid within the housing of the cleaning assembly; and

raising the housing away from the polishing surface to expel the cleaning fluid and residual contaminants from the polishing pad.

16. The method of claim 15, wherein the cleaning fluid is deionized water and droplets of the cleaning fluid are produced by subjecting the deionized water to a hydraulic pressure.

17. The method of claim 16, wherein the hydraulic pressure is less than about 60 psi.

18. The method of claim 17, wherein the deionized water droplets are further subjected to an air pressure less than about 10 psi.

* * * * *

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United States Patent [19]

Mullins

[11] **Patent Number: 5,578,529**

[45] **Date of Patent: N v. 26, 1996**

[54] **METHOD FOR USING RINSE SPRAY BAR IN CHEMICAL MECHANICAL POLISHING**

[75] Inventor: **James M. Mullins**, Austin, Tex.

[73] Assignee: **Motorola Inc.**, Schaumburg, Ill.

[21] Appl. No.: **459,231**

[22] Filed: **Jun. 2, 1995**

[51] **Int. Cl.**^{6} **H01L 21/304**; H01L 21/306; B08B 3/02

[52] **U.S. Cl.** **437/228**; 156/636.1; 451/287; 451/41; 134/6; 134/33

[58] **Field of Search** .... 437/228; 156/636.1, 156/645 LP; 451/283, 285, 287, 288, 41; 134/7, 6, 33

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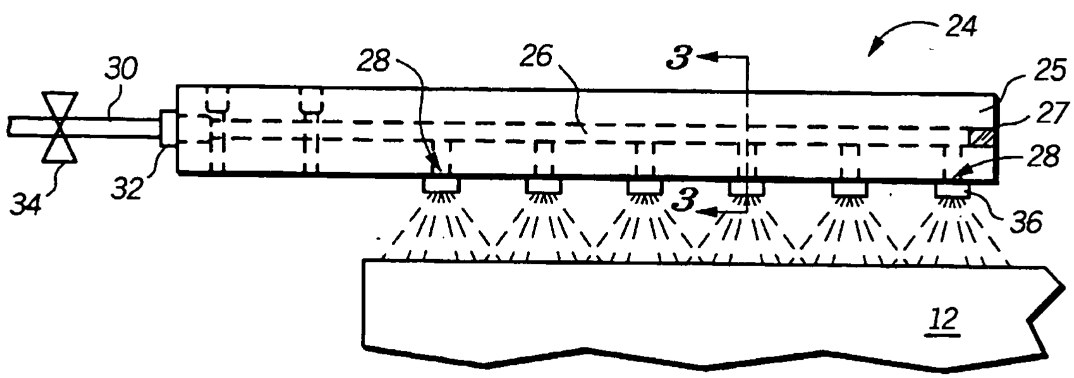
Primary Examiner—Robert Kunemund
Assistant Examiner—Matthew Whipple
Attorney, Agent, or Firm—George R. Meyer

[57] **ABSTRACT**

A rinse spray bar (**24**), added to CMP equipment (**10**), provides complete and uniform wetting and rinsing of the polishing pad (**12**) for an improved process. The rinse spray bar has a first opening (**26**) running through a portion of its length and multiple second openings (**28**) connected to the first opening to create multiple flow paths for a rinse agent. These second openings (**28**) are capped with spray nozzles (**36**) on the bottom surface of the rinse spray bar so that the rinse agent can be sprayed out from the second openings at a pressure higher than ambient such that the sprays patterns overlap each other to ensure uniform wetting. An in-line valve (**34**) adjusts and controls the pressure of the incoming rinse agent through the input line (**30**) so that the spray nozzle pressure can be varied. The rinse spray bar can be used at every polishing pad station in the CMP apparatus.

27 Claims, 1 Drawing Sheet



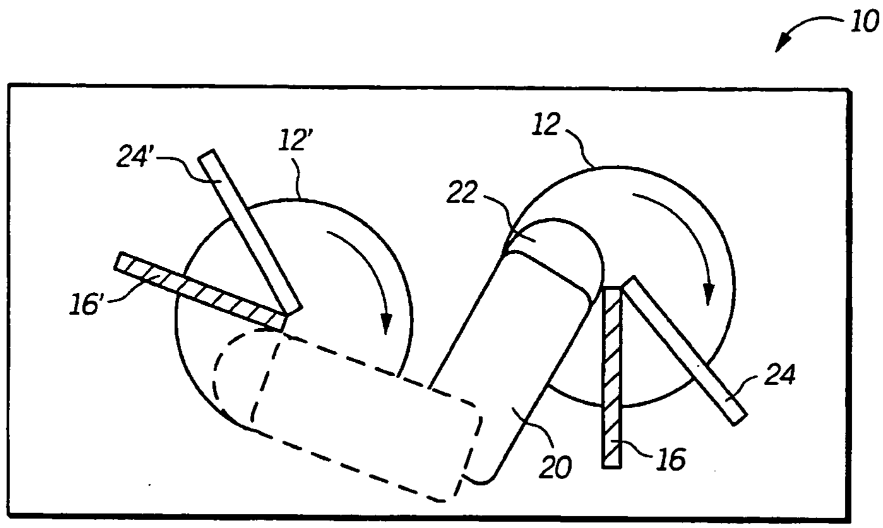


FIG.1

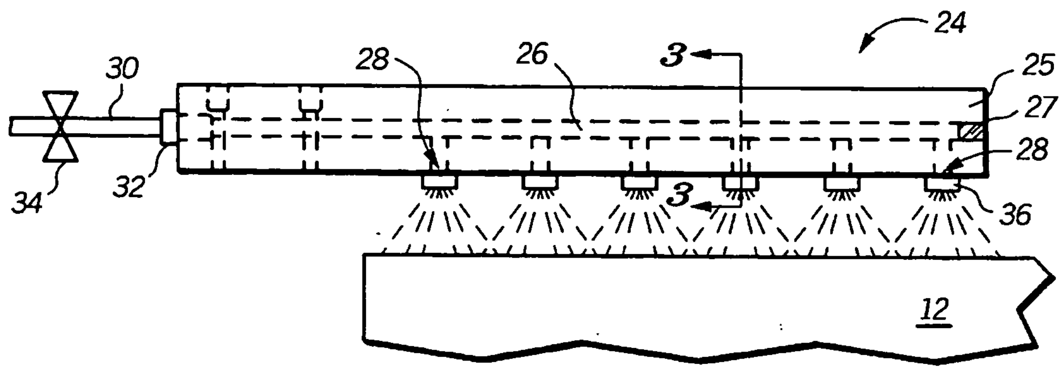


FIG.2

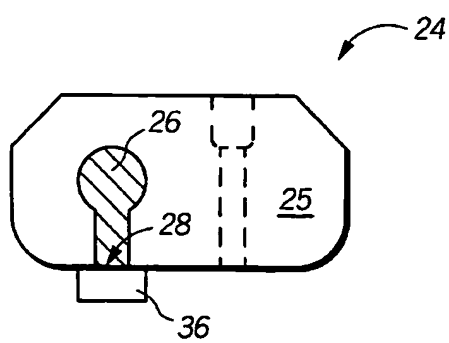


FIG.3

METHOD FOR USING RINSE SPRAY BAR IN CHEMICAL MECHANICAL POLISHING

FIELD OF THE INVENTION

The present invention relates in general to semiconductor processing and more specifically to a rinse spray bar for use in chemical mechanical polishing of a semiconductor wafer.

BACKGROUND OF THE INVENTION

One aspect of current semiconductor wafer processing generally involves forming dielectric layers alternating between metal layers on a semiconductor wafer. The formation of each layer, either dielectric or metal, often results in a conformal layer which corresponds to underlying surface topography. Planarization of the surface of these layers is frequently required. The art provides various methods for planarizing the wafer surface. One such method employs abrasive polishing to remove protrusions along the surface of the top layer on the semiconductor wafer. In this method, the semiconductor wafer is placed faced down on a table covered with a polishing pad which has been coated with a slurry or abrasive material. Both the wafer and the table are then rotated relative to each other to remove the protrusions on the surface of the wafer. This process of planarizing the wafer surface is generally referred to as chemical mechanical polishing (CMP).

An important part of the CMP process is the rinsing of the wafer and polishing pad. Presently, a tube is attached to the CMP equipment to dispense liquids onto the polishing pad at the center of the pad. The liquid being used for the rinsing step is water, although the tube is also equipped to dispense the slurry materials used in the polishing step. The tube extends toward the center of polishing pad and merely dispenses the water through an open hole at the end of the tube. This method relies on the centrifugal force generated by the rotation of the polishing pad to distribute the water over the entire surface of the polishing pad.

However, the prior art method has several disadvantages. One such disadvantage is that the water tends to travel radially outward from the center of the polishing pad in channels or rivulets instead of being evenly distributed over the entire surface area of the polishing pad as desired. The surface area between the water channels can remain dry. Consequently, uneven wetting of the polishing pad occurs, and the resulting polishing surface becomes non-uniform. This degradation in polishing pad surface results in low, unstable, and unpredictable polish rates leading to a non-uniform polished wafer surface which is undesirable. Another disadvantage is that the non-uniform polishing also shortens the useful life of the polishing pad which must then be replaced leading to longer equipment down time as well as adding to the cost of CMP.

Thus, a method for attaining a uniform wetting and rinsing of the polishing pad to maintain a saturated and stable surface for polishing to avoid an uneven polished wafer surface is desired.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates, in a top view, a schematic of a polishing apparatus to illustrate a method of use for a rinse spray bar of the invention.

FIG. 2 illustrates, in a side view, a rinse spray bar in accordance with the present invention.

FIG. 3 illustrates, in a cross-sectional view along line 3—3, the rinse spray bar of FIG. 2.

It is important to point out that the illustrations may not necessarily be drawn to scale, and that there may be other embodiments of the present invention which are not specifically illustrated.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The present invention provides, in one embodiment, a rinse spray bar for use in CMP to polish a semiconductor wafer. Embodiments of the invention may be used in conjunction with all polishing pad stations in the CMP apparatus. The rinse spray bar is composed of a chemically neutral, rigid, elongated member having a first opening running through a portion of its length for a rinse agent to flow therethrough. In addition, the rinse spray bar has multiple second openings, located along the length of the elongated member which are connected to the first opening so that the rinse agent has multiple flow paths. The centerlines of the second openings are substantially perpendicular to the centerline of the first opening. These second openings are capped with spray nozzles on the bottom surface of the elongated member so that the rinse agent can be sprayed out from the second openings at a pressure higher than ambient. The rinse spray bar is positioned above the polishing pad such that the spray nozzles are pointed downward to the surface of the pad and such that the rinse spray bar is substantially parallel to the surface of the pad. A line which dispenses the rinse agent is attached to the rinse spray bar. An in-line valve adjusts and controls the pressure of the incoming rinse agent so that the spray nozzle pressure can be varied as needed. The rinse spray bar may be turned on as needed during the CMP process to rinse off the slurry and the residue in the various polishing steps. The multiple nozzles spraying the rinse agent allow uniform wetting and rinsing of the polishing pad and the semiconductor wafer polished surface. These and other features, and advantages, will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings.

FIG. 1 illustrates, in a top view, a schematic of a CMP polishing apparatus **10** having a rinse spray bar **24** of the invention. As shown, the CMP apparatus **10** has two polishing pad stations: polishing pads **12** and **12'**. Polishing pad **12** is the primary or first polishing pad, while polishing pad **12'** is the fine or final polishing pad. Both polishing pads rotate during polishing as depicted by the arrows in the figure. The polish arm **20** holds a semiconductor wafer **22**, face down, over the surface of the polishing pad **12**. The polish arm **20** is movable to position the semiconductor wafer **22** over the surface of the final polishing pad **12'** once the wafer has undergone the initial polishing step. The tubes **16** and **16'** are part of the pre-existing apparatus. These tubes extend radially toward the center of the polishing pads and have only an open hole at the end of each tube to dispense either slurry or water at the center of the pad. These tubes **16** and **16'** have multiple purposes of dispensing both the needed slurries for the polishing steps and water for the rinsing steps. As stated previously, these tubes are limited to dispensing the liquids at the open hole at the end of the tubes. The present invention adds rinse spray bars **24** and **24'** to the CMP apparatus for an improved rinsing step leading to many advantages for the entire CMP process. The rinse spray bars **24** and **24'** also extend radially toward the center of the polishing pads. The exact angle between the tube **16**

and the rinse spray bar **24** is not critical. Rather, their locations can varied for a best fit with the existing apparatus in whatever space is available. The use of rinse spray bars has been reduced to practice on a Westech polishing system. However, the rinse spray bar's use is in no way limited to a Westech system but can be fitted for use with any CMP apparatus.

FIG. **2** illustrates, in a side view, the rinse spray bar **24** of FIG. **1** overlying the polishing pad **12** in accordance with the present invention. The rinse spray bar **24** is composed of an elongated member **25** having a first opening **26** running through a portion of its length. The length of the rinse spray bar **24** is dependent on the size of polishing pad because the bar needs to be sufficiently long to extend to the center of the polishing pad. However, unlike the tube known in the prior art, the rinse spray bar **24** of the present invention does not have an open hole at the end of the bar because the operation of the rinse spray bar is based on a different principle than the tube of the prior art. The end of the rinse spray bar **24** is closed, either by plugging the first opening **26** with a plug **27** or by not boring the opening completely through the length of the elongated member **25**. The plug **27** may be made of the same material as the elongated member **25** or any chemically neutral and non-reactive material. The prior art dispenses the rinse agent through an open hole at the end of the tube and relies on centrifugal force to distribute the rinse agent outwardly over the surface area of the polishing pad. This method is inefficient and has many shortcomings as discussed above.

In contrast, the rinse spray bar **24** of the present invention connects a series of second openings **28** disposed along the length of the elongated member **25** to the first opening **26** to form multiple flow paths for the rinse agent, as shown in FIG. **2**. Although not required, it may be preferable to progressively increase the size of the second openings, starting from the input end of the rinse spray bar **24**. For example, a diameter of 1/32 inch (0.79 mm) was used for the first second opening **28** closest to the input end, with each subsequent second opening becoming progressively larger by 1/32 inch (0.79 mm). These dimensions are only intended to be illustrative and not limiting. The major axes of the second openings **28** are approximately perpendicular to the major axis of the first opening **26**. Additionally, the second openings **28** are spaced approximately evenly apart along the length of the rinse spray bar **24** for an even dispersal of the rinse agent over the surface of the polishing pad **12**. A practical range for the spacing between two adjacent second openings **28** holes is from approximately 30 to 45 mm. The object is to obtain overlapping spray patterns for complete and uniform coverage of the polishing pad surface.

Spray nozzles **36** are required to be fitted to the second openings **28** to evenly disperse the rinse agent over the surface area of the polishing pad **12**. If spray nozzles **36** are not used, then only clean spots, corresponding to the locations of the second openings, can be observed on the polishing pad. This spotty cleaning leads to uneven aging of the pad and to non-uniform removal rates during the polishing steps. However, the spray nozzles **36** allow the rinse agent to be sprayed out at a pressure higher than ambient, and because the nozzles have an adjustable open position, the spray pattern is fan-shaped as illustrated in FIG. **2**. These spray patterns are designed to overlap one another to provide complete wetting of the surface area of the polishing pad.

The rinse agent is sourced from a line **30** that is attached to the input end of the rinse spray bar **24** with a connector **32**. The connector **32** can be of any generic kind, although a Flaretek connector was used in the reduction to practice. The rinse agent may be water or ammonium hydroxide (NH_4OH). Alternatively another suitable liquid may also be dispensed through the rinse spray bar **24**. An in-line valve **34** controls the incoming pressure of the rinse agent. In a reduction to practice, 0.375 inch (9.5 mm) teflon tubing was used for the line **30** and a needle valve was used to control the in-line pressure. However, other equivalent substitutes may also be used for the line **30** and in-line valve **34** without affecting the operation of the rinse spray bar **24**. The spray nozzles used in the reduction to practice are of the standard type known to one of ordinary skill in the art and are easily available through nozzle manufacturers. In practicing the present invention, it is desirable to set the separation distance between the bottom surface of the rinse spray bar **24** and the polishing pad **12** surface to a practical distance. Then the spray nozzles and in-line valve are adjusted to obtain uniform and overlapping spray of the liquid rinse agent. A pressure of 10 psi (69 kPa) above atmospheric pressure was used in the reduction to practice with a 1 inch (25 mm) separation but it is expected that a range of pressures from 5 to 15 psi (35 to 100 kPa) would be suitable for a practical separation distance. However, it should be understood that a pressure increase may allow the rinse spray bar and polishing pad to be spaced farther apart than the 1 inch used in the reduction to practice. Additionally, an increase in the pressure would allow the second openings (and their corresponding spray nozzles) to be spaced farther apart due to the overlap of the spray patterns.

A cross-section taken along line **3—3** illustrates the shape of the rinse spray bar **24** in more detail. As shown in FIG. **3**, the top edge of the rinse spray bar **24** is tapered or beveled to reduce accumulation of liquids on top of the rinse spray bar **24**. However, rounding of the corners may be sufficient to allow a liquid to drain off the top surface. Alternatively, the top surface of the rinse spray bar **24** may be sloped or domed to allow liquid drainage. Also in FIG. **3**, the shape of the first opening **28** is illustrated as being circular because a circular hole is the easiest to make. However, other shapes, such as an ellipse, may also be used as long as they are manufacturable. A circular hole diameter ranging from 5 to 10 mm is sufficient. A flat bottom surface is desired to affix the spray nozzles **36** and to maintain a set distance from each spray nozzle **36** and the polishing pad **12** surface.

The rinse spray bar **24** should be made from a rigid and machinable material that is chemically neutral and non-reactive to the chemicals used in the CMP process. The slurry used in CMP is very corrosive, having a pH of 14, so the material should be able to withstand those type of conditions. It is also important that the rinse spray bar **24** be composed of a sufficiently rigid material that does not warp or flex at the required length of the bar because the spray nozzles **36** on the bottom surface of the rinse spray bar **24** and the polishing pad **12** surface should be substantially parallel to each other for even spraying of the rinse agent. Polyvinylidine fluoride (PVDF) was the material successfully used in the reductions to practice where the rinse spray bars varied from 15.75 to 16 inches (40 to 41 cm) in length by 1 to 1.5 inches (2.5 to 3.8 cm) in width by 0.75 inch (1.9 cm) in thickness. However, practicing the invention is not limited to PVDF. Rather other materials meeting the required characteristics may be used. One such material is polymethyl methacrylate (PMMA). Additionally, physical dimensions for the rinse spray bar **24** may vary from those used in the reduction to practice. It is expected that a practical range for the length may vary from approximately 35 to 45 cm. A practical width would range from approximately 25 to 45 mm, and a practical thickness would range from 15 to 20 mm.

In a method of use for the rinse spray bar **24** in a CMP apparatus, the polish arm **20** which carries the semiconductor wafer **22** to be polished is positioned over the primary polishing pad **12**. The semiconductor wafer **22** and the polishing pad **12** are rotated relative to each other for a specified amount of time until the excess material from surface of the wafer is removed, typically several hundred angstroms of material. The rotational speed is controllable by the equipment controls and is in no way limiting to the use of the present invention. Once the desired amount of material has been removed from the wafer surface, the rinse spray bar **24** is turned on to disperse a rinse agent over the surface of the polishing pad. The rinse agent, which can be either water or ammonium hydroxide or another suitable liquid, removes residue on the wafer surface generated by the polishing step as well as cleans the polishing pad **12** for subsequent polishing of other wafers. After the first polishing step, it is typical for the semiconductor wafer **22** to be given a final polish on the final polish pad **12'**. The use of the rinse spray bar **24'** after fine polishing of the semiconductor wafer **22** helps to remove residue left in the scribe lines on the wafer surface from the polishing step.

The foregoing description and illustrations contained herein demonstrate many of the advantages associated with the present invention. In particular, it has been revealed that the present invention has many advantages over the prior art. It is simple yet very effective. Corrosion is not an issue because the plastic material used for the rinse spray does not react with CMP chemicals. Actual reduction to practice has shown that uniform wetting and rinsing of the polishing pad can be achieved through the use of the present invention. This leads to uniform removal rates which is a dramatic improvement over the prior art where uneven removal rates were common because of the non-uniform wetting and rinsing of the polishing pad with the tube. This uniformity in removal rates, achieved through use of rinse spray bars, adds greater predictability to the CMP process. The use of the rinse spray bar also has the advantage of extending the life of the polishing pad by allowing uniform aging of the pad. Additionally, residue buildup from prior polishing steps can be rinsed away with the pressurized sprays of rinse agent. Another major advantage to the present invention is that it is extremely cost effective. The rinse spray bar is easily made in a machine shop using readily available and inexpensive materials.

Thus it is apparent that there has been provided, in accordance with the invention, a rinse spray bar for use in a CMP process that fully meet the need and advantages set forth previously. Although the invention has been described and illustrated with reference to specific embodiments thereof, it is not intended that the invention be limited to these illustrative embodiments. Those skilled in the art will recognize that modifications and variations can be made without departing from the spirit of the invention. For example, the dimensions of the rinse spray bar may be varied from those discussed. Likewise, the number of holes and spray nozzles may also be varied depending on the length of the rinse spray bar as well as the surface area to be covered. In a variation on a method of use, one can polish the surface of the semiconductor wafer using a slurry. Then a rinse step using water through the rinse spray bar uniformly wets and rinses the surface of the polishing pad and the polished wafer surface. Next, ammonium hydroxide is dispensed to clean the surface of the wafer. The ammonium hydroxide may also be dispensed through the rinse spray bar **24'**. The rinse spray bar may be manufactured with multiple first openings to accommodate the dispersal of different types of liquids. Therefore, it is intended that this invention encompasses all such variations and modifications falling within the scope of the appended claims.

I claim:

1. A method for polishing a semiconductor wafer, comprising the steps of:

providing a rinse bar connected to a CMP apparatus, the rinse bar having an elongated member that has:
first and second ends,
a first opening along a portion of a length of the elongated member for a rinse agent to flow from the first end toward the second end, and
a plurality of second openings on a surface of the elongated member, wherein the plurality of second openings is spaced along the length of the elongated member, and wherein the plurality of second openings is connected to the first opening for the rinse agent to flow from the first opening into the plurality of second openings;

positioning the rinse bar, with the plurality of second openings pointing downward, over a polishing pad, wherein the rinse bar extends from a point near an edge of the polishing pad toward a point near a center of the polishing pad;

polishing a surface of a semiconductor wafer with the polishing pad to form a polished surface; and

introducing the rinse agent at a pressure no greater than approximately 15 psi above atmospheric pressure through the rinse bar onto the polishing pad while the semiconductor wafer overlies the polishing pad to clean the polished surface.

2. The method of claim **1**, wherein the step of positioning the rinse bar comprises locating the rinse bar at approximately 25 millimeters above the polishing pad.

3. The method of claim **1**, wherein the step of introducing the rinse agent introduces a liquid selected from a group consisting of water and ammonium hydroxide.

4. The method of claim **1**, wherein the step of positioning the semiconductor wafer comprises positioning a wafer having a metal surface layer.

5. The method of claim **1**, wherein the step of introducing the rinse agent introduces said rinse agent at approximately 5 to 15 psi above atmospheric pressure.

6. The method of claim **1**, wherein the step of introducing is performed such that all points along a spraying line segment along the polishing pad are simultaneously sprayed, wherein the spraying line segment is a line segment along the polishing pad that has a first line segment end directly underlying the second opening that lies closest to the first end of the rinse bar and a second line segment end directly underlying the second opening that lies closest to the second end of the rinse bar.

7. The method of claim **1**, wherein the step of providing a rinse bar is performed such that the rinse bar has a plurality of spray nozzles, each spray nozzle being attached to one of the plurality of second openings, each spray nozzle having an adjustable open position such that the rinse agent may be dispensed from the rinse bar at a pressure higher than ambient pressure.

8. The method of claim **1**, wherein the step of providing a rinse bar is performed such that the CMP apparatus includes a slurry feed means.

9. The method of claim **1**, wherein the step of introducing is performed such that none of the rinse agent flows through the second end of the rinse spray bar.

10. A method for polishing a semiconductor wafer, comprising the steps of:

providing a rinse spray bar connected to a CMP apparatus, the rinse spray bar having

an elongated member, composed of a polymer, having first and second ends, a first opening through a portion of a length of the elongated member for a rinse agent to flow from the first end toward the second end, and a plurality of second openings on a surface of the elongated member, wherein the plurality of second openings is spaced along the length of the elongated member, and wherein the plurality of second openings is connected to the first opening for the rinse agent to flow into the plurality of second openings; and

a plurality of spray nozzles, each spray nozzle being attached to one of the plurality of second openings, each spray nozzle having an adjustable open position such that the rinse agent may be dispensed from the rinse spray bar at a pressure higher than ambient pressure;

positioning the rinse spray bar, with the plurality of spray nozzles pointing downward, over a polishing pad, wherein the rinse spray bar extends from a point near an edge of the polishing pad toward a point near a center of the polishing pad, and wherein the rinse spray bar is approximately parallel to a surface of the polishing pad;

polishing a surface of a semiconductor wafer with the polishing pad to form a polished surface; and

spraying the rinse agent at a pressure no greater than approximately 15 psi above atmospheric pressure through the rinse spray bar in overlapping spray patterns onto the polishing pad while the semiconductor wafer overlies the polishing pad to clean the polished surface.

11. The method of claim **10**, wherein the step of positioning the rinse spray bar comprises locating the rinse spray bar at approximately 25 millimeters above the polishing pad.

12. The method of claim **10**, wherein the step of spraying the rinse agent introduces a liquid selected from a group consisting of water and ammonium hydroxide.

13. The method of claim **10**, wherein the step of spraying the rinse agent sprays said rinse agent at approximately 5 to 15 psi above atmospheric pressure.

14. The method of claim **10**, wherein the step of polishing the surface of the semiconductor wafer is performed on a primary polishing pad.

15. The method of claim **14**, wherein step of polishing the surface of the semiconductor wafer is performed on a final polishing pad and wherein the step of spraying the rinse agent sprays water.

16. The method of claim **10**, further comprising the step of spraying ammonium hydroxide after the step of spraying water to remove residue from scribe lines on the polished surface of the semiconductor wafer.

17. The method of claim **10**, wherein the step of spraying is performed such that none of the rinse agent flows through the second end of the rinse spray bar.

18. The method of claim **10**, wherein the step of providing is performed such that the CMP apparatus includes a slurry feed means.

19. A method for polishing a semiconductor wafer, comprising the steps of:

providing a CMP apparatus having a slurry feed means, a rinse bar, and a polishing pad connected to a CMP apparatus, wherein the rinse bar includes:

an elongated member having first and second ends;

a first opening along a portion of a length of the elongated member for a first rinse agent to flow from the first end toward the second end; and

a plurality of second openings on a surface of the elongated member, wherein the plurality of second openings is spaced along the length of the elongated member, wherein the plurality of second openings is connected to the first opening for the first rinse agent to flow from the first opening into the plurality of second openings;

positioning the rinse bar over the polishing pad, such that the rinse bar extends from a point near an edge of the polishing pad toward a point near a center of the polishing pad and such that the plurality of second openings points downward toward the polishing pad;

polishing a surface of a semiconductor wafer by using the polishing pad to form a polished surface; and

introducing the first rinse agent at a pressure no greater than 15 psi above atmospheric pressure through the rinse bar onto the polishing pad while the semiconductor wafer overlies the polishing pad to clean the polished surface.

20. The method of claim **19**, wherein the step of introducing the first rinse agent introduces a liquid selected from a group consisting of water and ammonium hydroxide.

21. The method of claim **19**, wherein the step of positioning the semiconductor wafer comprises positioning a wafer having a metal surface layer.

22. The method of claim **19**, wherein the step of introducing the first rinse agent introduces said first rinse agent at approximately 5 to 15 psi above atmospheric pressure.

23. The method of claim **19**, wherein the step of introducing is performed such that all points a along a spraying line segment along the polishing pad are simultaneously sprayed, wherein the spraying line segment is a line segment along the polishing pad that has a first line segment end directly underlying the second opening that lies closest to the first end of the rinse bar and a second line segment end directly underlying the second opening that lies closest to the second end of the rinse bar.

24. The method of claim **19**, wherein the step of providing a rinse bar is performed such that the rinse bar has a plurality of spray nozzles, each spray nozzle being attached to one of the plurality of second openings, each spray nozzle having an adjustable open position such that the first rinse agent may be dispensed from the rinse bar at a pressure higher than ambient pressure.

25. The method of claim **19**, wherein the step of providing is performed such that the slurry feed means is a slurry feed tube.

26. The method of claim **25**, wherein the step of polishing comprises a step of slurry feed tube dispenses a slurry near the center of the polishing pad.

27. The method of claim **25**, wherein the step of introducing further comprises a step of introducing second rinse agent through the slurry feed tube to the polishing pad.

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